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INDUSTRIAL ADMINISTRATION

A SERIES OF LECTURES

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NOTE

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CONTENTS

	PAGE
SOCIAL OBLIGATIONS OF INDUSTRY TO LABOUR. By B. SEEBOHM ROWNTREE, J.P.	1
THE APPLICATIONS OF PSYCHOLOGY TO INDUSTRY. By T. H. PEAR, M.A., B.Sc., Professor of Psychology in the Uni- versity of Manchester	23
EDUCATION AS A FUNCTION OF MANAGEMENT. By A. E. BERRIMAN, O.B.E., M.I.Mech.E., Chief Engineer, Daimler Works, Coventry	49
OCCUPATIONAL DISEASES. By T. M. LEGGE, C.B.E., M.D., D.P.H., H.M. Medical Inspector of Factories	79
ATMOSPHERIC CONDITIONS AND EFFICIENCY. By LEONARD HILL, M.B., F.R.S., Director of the Department of Applied Physiology, Medical Research Committee	99
INDUSTRIAL COUNCILS AND THEIR POSSIBILITIES. By T. B. JOHNSTON, J.P.	133
TRAINING FOR FACTORY ADMINISTRATION. By ST. GEORGE HEATH	161
INDUSTRIAL FATIGUE. By A. F. STANLEY KENT, M.A., D.Sc., Director of the Department of Industrial Administration in the College of Technology, Manchester	185
INDEX	197

**SOCIAL OBLIGATIONS OF INDUSTRY
TO LABOUR**

Social Obligations of Industry to Labour

BY B. SEEBÖHM ROWNTREE, J.P.

A LECTURE GIVEN ON TUESDAY, 12TH NOVEMBER 1918

THE fundamental principle on which I base what I am going to say, is that Industry should everywhere and always serve the needs of citizenship. It is not an end in itself: it is but a means to the welfare of the whole community. Industrial enterprise cannot justify itself by enriching a few if it be at the expense of the many. It is only justified if it can answer a threefold test.

- (1) It must produce something of service to the community.
- (2) It must produce it under good conditions.
- (3) It must sell at a reasonable price.

These I take to be the social obligations which Industry should fulfil. To-day, however, we shall merely consider its responsibilities to one group in the community—albeit the largest group, representing four-fifths of the whole. I mean, of course, the workers.

As my time is limited, I shall not, except indirectly, deal with selling prices, nor with the character of the product of industry, beyond saying that I think all manufacturers should certainly ask themselves whether the goods they produce really benefit the world, or whether we should be as well, or perhaps even better off, without them.

And since the working classes, partly because of lack of education, and partly because of lack of means, can hardly, as yet, discriminate so carefully as the wealthier classes between good and bad, or beautiful and ugly

SOCIAL OBLIGATIONS OF INDUSTRY

articles, both manufacturers and salesmen should help them to do so.

I now pass to the question which every employer must ask himself: "Under what conditions are my goods produced?" I venture to say that too little attention has been devoted to this aspect of industry, *for various reasons. Industry, as we know it to-day, is a modern development. The factory system was unknown 150 years ago. Railways, which now employ about 700,000 people, are the growth of the last 180 years. It is only 140 years since the first cotton mill was established in Lancashire. In 1875 our output of coal was less than half what it is to-day, and our present output of iron is four times as large as it was fifty years ago.*

Day by day, through the introduction of the present system of financing industry, by the formation of limited liability companies, industrial organisations grow vaster, and their growth is quickened by the increasing frequency of amalgamation.

All these developments have resulted in an altered relationship between employer and employed. In the old days the master usually knew his men intimately. Now, the relation between the directors of a great industrial company and their thousands of "hands," is less human than mechanical, less vital than arbitrary and accidental. A wide, invisible gulf has opened between employers and workers, which must be bridged before those on one side may understand the needs and aspirations of those on the other.

If we, who are employers, or who represent employers, wish to fulfil aright our function in the community, we must try to understand and to define the duties which we owe to the workers, in return for their co-operation in the industrial enterprise on which they and we are jointly engaged. I think these may be considered under two headings.

SOCIAL OBLIGATIONS OF INDUSTRY

First, we owe it to them that the material conditions under which they work shall be satisfactory. Of these conditions the most important is the weekly wage. Are we paying to all our workers wages that will enable them to live in health and comfort, with some opportunities for self-realisation? This question is so important that I make no apology for discussing it in some detail. I deal only with the minimum wages, and submit that these should be determined by the human needs of the workers, wages above the minimum being fixed by the haggling of the market.

Dealing first with the wages of the men, which, since 90 per cent of them marry, must be based on the needs of married men, I think that the minimum standard, below which they should never be allowed to fall, may be thus stated: A man's wage should enable him to marry, to occupy a decent house, and to bring up a family of normal size in a state of physical efficiency, while allowing a reasonable margin for contingencies and recreation. Before we can estimate the wages which will enable a man to live according to this standard, we must decide what number of dependent children to allow for. I have recently made a detailed investigation in order to ascertain what proportion of married men have children dependent upon them, how many children, and for what number of years. I will return to this subject later, and meanwhile I may say that the inquiry shows quite conclusively that we must allow for at any rate three dependent children in estimating the human needs of men.

Now, what sum will enable a man to maintain a family of five in accordance with the standard I have just outlined? We will take the chief items of necessary expenditure. First comes food. The amount of food required for the maintenance of physical efficiency varies with the severity of the work performed. We are certainly not over-stating the case if we assume that

SOCIAL OBLIGATIONS OF INDUSTRY

the labour of the majority of industrial workers falls half-way, as regards severity, between such heavy work as that of a stoker or blacksmith, and light work such as that of a sedentary worker. As for the rest of the family, we all know that the wives of most industrial workers are busy all the day long on household tasks, some of which are heavy, and that the children, who have no charming nurseries like the children of the well-to-do, are "always knocking about." Thus we are justified in adopting for the whole household the dietary required by a moderate worker. Basing our estimates on 1914 prices, since prices at the moment are so extraordinarily unstable, the necessary food for a family of five engaged on moderate work will cost 15s. 1d. a week, if the dietary is selected with the utmost regard to economy, and with accurate scientific knowledge of the nutritive values of different food-stuffs. I want to emphasise the fact that the estimate is a modest one. In point of fact, the dietary provided is more economical, having regard to its nutritive value, though more varied and consequently more attractive, than that provided for prisoners and paupers, and considerably more economical than the dietary which is actually chosen by workers in the ordinary way.

The amount which must be allowed for rent varies, of course, from one district to another; but except for extremes at both ends of the scale, we shall not be far wrong if we allow 6s. as the rent which must be paid for a house providing the minimum accommodation necessary for a normal working man's family.

From a number of systematic inquiries, which I have made from working people with practical knowledge, I place the minimum cost of clothing a family of five at 5s. a week. This allows 1s. 9d. a week for the man, 1s. for his wife, and 9d. a week each for the three children.

Next we must provide about 1½ cwt. of coal a week,

SOCIAL OBLIGATIONS OF INDUSTRY

which, at average prices ruling in 1914, may be put at 2s. 6d.

Then come household and personal sundries. The former include such items as lighting, cleaning materials, replacement of broken crockery, and so forth. I estimate these at 4d. per head, or 1s. 8d. for the family. Personal sundries I put at 5s. These include the man's travelling expenses to and from work, compulsory health insurance and a contribution to a second sick club, and trade union subscription, expenditure on beer and tobacco, sick and burial clubs for wife and children, and outlay on recreation. Adding up the various items, we find they come to 35s. 3d., made up as follows :

	s.	d.
Food	15	1
Rent	6	0
Fuel	2	6
Clothing	5	0
Sundries—		
Household	1	8
Personal	5	0
	35	3

I think it will be admitted that this figure does not allow for an extravagant mode of life. Indeed, it is open to the criticism that it is an under-estimate of what a minimum wage should provide for. And yet, in 1911 Professor Bowley estimated that only one in four of the eight million adult male wage earners in regular employment in this country earned more than 35s. a week, and 2½ million of them earned 25s. or less. Wages rose but slightly between 1911 and 1914, so we may take these figures as approximately representing the situation at the outbreak of war.

Now let us turn to the question of women's wages. Here we must first decide whether they shall be based on the human needs of the individual workers, or

SOCIAL OBLIGATIONS OF INDUSTRY

whether they shall include some allowance for dependents. From such evidence as I have been able to obtain, I have come to the conclusion that no allowance for dependents should be made in the case of women's wages. With a view to throwing light on this subject, I recently made an inquiry which, though limited to about 560 cases, was very detailed, and I found that five-sixths of the women investigated had no dependents. Those who had were in that position through some accidental cause, such as the death, or illness, or unemployment of the male wage earner, etc., etc. Certainly the situation thus arising must be dealt with, but I submit that we should deal with it directly, by such methods as that of greater unemployment insurance, etc., not indirectly through the women's wages. In estimating men's wages, I have made no allowance or exceptional circumstances which lead to increased expenditure, therefore in adopting this point of view I am not dealing with women on a different principle.

I submit that women's wages should be such as will enable her to live in a decent dwelling, and to maintain herself in full physical efficiency, with a reasonable margin for contingencies and recreation. Most women engaged in industry who do not live at home, lodge with other families. Before the war the sum most commonly paid for board and lodging was about 12s., and we take this as the basis of our estimate.

After making inquiries from a large number of working women as to the sum which should be allowed for clothing, I put this down at 4s. This is more than I allowed for a working man's wife, for two reasons. First, a woman who is going to work has to wear better clothes and wears them out more quickly than one who is usually at home, and who does her work in her very oldest garments; and, secondly, an unmarried woman's chance of making a good match depends to no small

SOCIAL OBLIGATIONS OF INDUSTRY

extent upon her ability to dress nicely. There remains expenditure for personal sundries, and here again I allow 4s., which, as in the case of the men, must cover travelling to and from work, national health insurance, and a contribution to a second sick club, trade union subscription, recreation, and a host of small but necessary items, such as stamps, occasional railway journeys, and so forth.

The above items total up to £1, namely :

Board and Lodging	s.	d.
Clothing	4	0
Sundries	4	0
	<hr/>	
	20	0

The above estimate is framed in the same cautious spirit as my estimate for men's minimum wages, and I do not think that a lower figure could possibly be defended. Yet before the war, it is doubtful whether one in ten of the four million women workers was earning £1 a week. Wages of 8s. and 9s., and even lower, were common in many parts of the country, and many hundreds of thousands, possibly millions of women, were working for less than 15s.

But it must be remembered that up to now we have spoken in terms of prices as they ruled in 1914. If we were to take present prices, our minimum wages would have to be far higher. Prices to-day are, of course, abnormal, but, on the other hand, they are not at all likely to return to their 1914 level. No one can precisely foretell the post-war normal cost of living, but even if it drops to 25 per cent above the level of 1914, then the minimum wages must be 44s. for men and 25s. for women. If it fails to drop so low, then the minimum wage must be correspondingly increased, but it would be very optimistic to assume that it may drop lower.

SOCIAL OBLIGATIONS OF INDUSTRY

The question at once suggests itself: "Can industry afford to pay minimum wages such as I have indicated?" Obviously it would not be in the interests of workers, by statute or otherwise, to fix a minimum wage at so high a level as to cripple industry. Increased wages may come from four sources. They may come from the consumers, from whom we may ask increased prices for the goods supplied to them. But this method can only be employed to any extent in the case of goods which are not consumed by wage earners, because our minimum wage will rise and fall with the cost of living, and any attempt to meet the added charge on industry by raising prices indiscriminately will only involve a proportionate increase in the wage.

Secondly, increased wages to some extent may come directly from the workers, since their efficiency may increase with their earnings. It is poor economy to pay them so low a wage that they cannot afford the necessities of a healthy life. There is not the least doubt that large numbers of our labouring people have in the past been inefficient simply because of their low wages. Neither their bodies nor their brains have been adequately nourished. Again, workers who are chronically labouring under a sense of injustice, and who feel that they are being paid what they call "starvation wages," will never do their best. Still, making allowance for these facts, I do not think that we can expect a large proportion of the increase in wages to come from this source.

The third possible source of an increase is the profits of employers and shareholders. Something may doubtless be done by way of reducing them, and in so far as this is possible without imperilling an industry I do not think the prospect need alarm us. But although I cannot support the statement with any volume of statistical evidence, I do not believe for a moment that there is in the average industry any vast reservoir of

SOCIAL OBLIGATIONS OF INDUSTRY

profits in excess of those necessary to maintain it in a healthy condition, into which workers may dip for higher wages.

I believe that the fourth, and the principal, source to which we must look for increased wages is increased efficiency in the organisation and administration of industrial enterprises. The outlook here is almost unlimited, and one of the principal social obligations of the employing class is to conduct industry so efficiently that the payment of high wages is possible. Obviously I cannot enter into this subject at any length ; indeed, it is one which this department exists to study. But I may indicate the broad lines on which development is urgently needed.

In the first place, if I may quote from one of my own articles :

“ Many British factories at present are run on very inefficient lines. Much of the machinery is antiquated, the works are ill-arranged, and the staff and workers are ill-trained. In such cases, even when wages are low, the profits are inconsiderable, and any request for higher wages is met by the argument that the industry cannot afford them. What is here needed is a critical examination of each process, to see whether the productivity of every unit of labour cannot be increased. A skilled engineer, preferably one who is acquainted with the particular industry, should be set aside for the work, or called in to undertake it. He should have no routine executive duties, but simply concern himself with checking leakage and improving efficiency. If he is the right man there are few factories in which he will not very soon be able to effect important economies. He will (perhaps with the aid of an accountant) closely analyse the working costs, and, if possible, compare them with costs elsewhere.

SOCIAL OBLIGATIONS OF INDUSTRY

The splitting up of costs and their comparison with those in other factories are a wonderful means of *enabling an employer to place his finger on the weak spots.* It is not enough to compare the total working costs with those of other manufacturers—they must be split up as minutely as possible. An accountant of great experience told me that he recently came across a case where the total working costs of a group of employers engaged in making a certain article only varied by about 5 per cent, but the costs of some of the particular processes varied by as much as 60 per cent. It is these variations that we must trace if we are to find out where waste is occurring.

“Only when every process in the factory has been submitted to a minute examination is an employer really in a position to say whether his industry can or cannot afford to pay higher wages.”

If, in addition to this systematic overhauling, all the resources opened up by engineering and chemical research are utilised by industries, vast developments will follow. Of course, they will take time, and I do not advocate the immediate fixing by Parliament of a minimum wage to be universally paid. I believe, however, that Parliament should forthwith enact that Trade Boards shall be set up for all industries, including agriculture, and that within a strictly limited period, say five, or at the most seven, years, minimum wages shall be paid which will enable a man to marry, and to maintain a family of normal size in a state of physical efficiency, with a margin for contingencies and recreation, and which will enable women to live in decent dwellings and to support themselves in full physical efficiency, with a similar margin. Some industries could afford these minimum wages more quickly than others, and they should be paid at the earliest possible

SOCIAL OBLIGATIONS OF INDUSTRY

date, but they must be paid in all industries within the prescribed period. An industry which, after making every effort, cannot within a reasonable time afford to pay them is, speaking generally, a parasitic industry whose continued existence is not to the advantage of the nation.

I recognise, of course, that agriculture, if we may call it an industry, could not be scrapped, even if it should be found that farmers could not pay the minimum wages and still farm at a profit. This contingency, to a mere outsider, seems improbable. I have not enough knowledge of the subject to offer an opinion, but certainly great improvements are possible in agricultural methods, as would be demonstrated if proper costing schemes were introduced. But I would here point out that even if permanent aid were given to farmers, it must not be such as would raise the cost of foodstuffs consumed by the workers. Such a course would only necessitate raising the minimum wages to meet the increased cost of living.

Before I pass from the subject of wages, there is one important point to which I must refer. Hitherto we have assumed that a man's wage should be sufficient to provide for three dependent children, but inquiries which I have recently made show clearly that if we only fix the minimum wage on such a basis, a very large proportion of the children of men receiving it will for a number of years be inadequately provided for. My investigation shows that 54 per cent of these children belong to families where for five years or more there are four or more children dependent on the earnings of the father, and 38 per cent to families where for five years or more there are five or more children dependent on the earnings of the father.

These facts speak for themselves, and it is imperative to provide some means of safeguarding the larger families. In so far as the problem can eventually be

SOCIAL OBLIGATIONS OF INDUSTRY

met by raising the minimum wage, well and good. This, no doubt, is the ideal at which wage boards should aim. But even to fix the minimum generally at a level which will provide for a family with three dependent children means a heavy demand on the resources of industry; and at present there is little prospect of establishing a minimum sufficient for larger families. Unless, therefore, we are to continue to allow a large proportion of the nation's children to pass through some of the most critical years of their lives ill-housed, ill-clad, and underfed, we must seek some other solution of the problem which confronts us. The only possible alternative—and I admit that it is fraught with many difficulties—is to fix minimum wages sufficient to secure physical efficiency for, say, three dependent children, and for the State to make a grant to the mother in such cases and for such a time as there are more than three dependent children. This suggestion may appear revolutionary, but it is nothing new. Such a principle is already admitted in the case of the income tax, where a substantial abatement is made for every child. If Parliament has recognised the need for such a State grant to families with an income of not less than £130 a year, surely a much stronger case can be made out for a similar grant where the income is smaller. Again, the State graduates its separation allowance for soldiers' wives according to the number of dependent children.

I estimate that the cost of providing 3s. a week for all dependent children in excess of three per family would be a little over eight million pounds per annum.

I now pass from the subject of wages to other social obligations of industry to labour, and will deal next with hours of work. I believe that in most industries the working day is at present unnecessarily long, and could be reduced without any material reduction in output. We ought to aim at a working week of not more than

SOCIAL OBLIGATIONS OF INDUSTRY

48 hours. I do not, of course, pretend to dictate to employers in every industry, and to tell them that they can actually reduce their hours to 48 without reducing output. But I am confident that it can be done to a far greater extent than is generally supposed, and that long hours are often the result, not of necessity, but of custom. Short hours may effect economies for three reasons. (1) Long hours usually involve starting at six o'clock, and working two hours before breakfast. Work done before breakfast is notoriously unsatisfactory. (2) By shortening the working day, there need only be one break for meals instead of two. Employers know very well that more time is lost in such a break than is actually allowed for the meal. There is a wonderful leakage of minutes between leaving off and beginning again ! (3) A man can work more strenuously and do more per hour when working a short day than when working a long day. I know that in many industries the output is largely regulated by the speed at which the machinery works. But even here it will often be found on close examination that a keen and alert worker, one who wastes no time in starting and stopping, or in putting work in and taking it out again, can get as much out of a machine in 48 hours as a less vigorous worker will do in 53. While, therefore, I do not say that a reduction in output will never follow a reduction in working hours, I submit that it is the duty of employers to take the initiative in seeking to reduce the working week to a 48 hours limit. They should never be satisfied until they have reached it. If each employer in his factory will attack the problem in the right spirit, I have not the least doubt that within a very short period an important reduction may be effected in the length of the working week without injury to industry. The workers, of course, should bear in mind that the shortening of hours without a reduction in wage is in most industries only practicable

SOCIAL OBLIGATIONS OF INDUSTRY

if, while they are at work, they work hard and waste no time.

I said at the outset of my address that everywhere the claims of citizenship must take precedence of the claims of industry. I recognise, of course, that we cannot afford, especially at the present time, to impoverish the country by lowering the output of industry, but I want us all to recognise the importance of giving the workers a reasonable margin of leisure. We want them to make the most of their brains, to utilise their spare time in self-improvement and in the study of social and political problems. But is it reasonable to ask a man who has left home at five in the morning and does not return until six at night, to turn out after tea to attend a class, or to grapple with some serious subject? Short hours are simply essential if we are to have an educated democracy. In this connection I should like to put in a plea for greater consideration on the part of employers in respect of night work and alternate shifts. These interfere seriously not only with the amenities of home life, but with the opportunity of the workers to attend evening classes. A man who is on nights one week and on days next, inevitably misses alternate lectures in a consecutive course. I know that in certain cases night work is inevitable, but we should reduce it to the lowest possible limit.

The third obligation of industry to the workers is greatly to lessen, if not to remove entirely, the evil of unemployment. This problem should be attacked from two standpoints. First, we should seek to reduce the total amount of unemployment, and, second, to reduce the hardships caused by such unemployment as cannot be prevented. It is of vast importance, not only to the workers, but to the whole of industry that we should achieve these ends. When peace is declared we shall have to face a serious economic situation, and it is urgently necessary to create new wealth as rapidly

SOCIAL OBLIGATIONS OF INDUSTRY

as possible, to make good the enormous loss we have sustained through the war. This will mean, among other things, that we must introduce labour-saving machinery, and more capable administration, and also persuade the worker not to limit output. But we can hardly expect him to sympathise with our efforts so long as they may expose him to the risk of immediate suffering through unemployment. Although we know that in the long run greater individual efficiency does not increase, but tends to reduce, the amount of unemployment, its immediate effect may be to throw individuals out of work. We must remove the dread of this contingency before we can enlist the hearty co-operation of the workers.

I suggest that employers of labour should give their workers a guarantee that no man shall suffer through the introduction of labour-saving machinery, or alterations which lead to a greater output per worker. This might occasionally mean that they were saddled with a few superfluous workers, but there is always a leakage of workers from a factory through natural causes, and those displaced through the above improvements could usually very soon be absorbed in other parts of the factory. Any loss occasioned by the temporary payment of men for whom there was not full work would probably be more than made good by the spirit which a sense of safety would create among the workers. It is possible that in order to make such a guarantee as I have suggested practicable, it should be given by a federation of the employers engaged in an industry rather than by individuals.

Unemployment, of course, may be due to other causes than the introduction of more efficient methods of production. Wherever it affects a few workers only in a factory, every effort should be made to find other work for them either in the factory concerned or elsewhere. With a little thought it is often possible,

SOCIAL OBLIGATIONS OF INDUSTRY

especially in a large factory, to provide useful work for a man who would otherwise be discharged. Still, when all has been done that can be done in this direction, there will inevitably be times when unemployment is unavoidable. To meet such a contingency, I think that unemployment insurance should be made universal and compulsory, and that the present unemployment benefit of 7s. should be very largely increased. This is not a Utopian policy. On the average, 95 per cent of the workers are employed, and only 5 per cent out of work, and thus, to pay full wages to unemployed persons, which by the way is a course I should not recommend, would only involve a tax equal to 5 per cent on the present wage bill. I suggest that, if a scheme of universal unemployment insurance were introduced, with a benefit on a high scale, individual industries should be permitted to contract out of it, if they could satisfy the authorities that their own provision for unemployed persons was at least as good as that provided under the national scheme. I doubt whether we realise half so acutely as we ought to do the anxiety and distress which are caused by unemployment. Nor do we realise the deterioration in national physique, and in the morale and character of the workers, which it occasions when it is frequent or long continued.

There is only one other social obligation of industry to labour, on what I may call the material side, to which I propose to refer. It is that more attention should be paid to their working environment. In planning a factory we should always bear in mind, not only its suitability for the mechanical processes to be carried on, but the comfort and health of the men and women who are to work in it. The worker will not be the only one to benefit by such consideration on our part. Anything which promotes his health and comfort tends to make him more efficient. I emphasise this point, not

SOCIAL OBLIGATIONS OF INDUSTRY

because I am "out for big dividends," but because I do not wish to see improvements which are desirable, in whatever aspect we regard them, idly dismissed as "impracticable."

We want, then, to see that what may be termed the "welfare" conditions in our factories are satisfactory. Workrooms should be properly ventilated and adequately warmed. Careful thought should be given to lighting, so that the eyes of the workers may not be unduly strained. A high standard of cleanliness should everywhere be maintained. Adequate provision should be made for washing, and suitable cloak-room accommodation provided. Then, might we not do rather more to make the workrooms brighter and more cheerful? A few carefully selected pictures and plants make a great difference.

Where employees stay at the factory for dinner, the provision of a good canteen is a matter of real moment. It is not enough to provide a bare and comfortless dining-room. The dinner hour should be a period of real recreation—a time when the workers' powers are re-created. Well-cooked and nourishing food should be available, and rooms set apart in which it can be eaten under restful and congenial conditions. There are many other provisions of a similar character which may suitably be made in our factories, but I have not time to dwell upon them. They will occur to all employers who steadfastly bear in mind their responsibilities to the workers, regarded not as automata but as human beings. Such employers will always refrain from asking others to work under conditions which they would not themselves tolerate.

Hitherto, I have dealt with the material environment which surrounds the worker. I now pass to a further social obligation of industry to labour, namely, to create in the factory a tone and atmosphere which will encourage every worker to be and to do his best.

SOCIAL OBLIGATIONS OF INDUSTRY

Employers have hardly recognised the extreme complexity and delicacy of the human machine. We often treat "Labour" in the mass, and forget that it is made up of a number of separate individuals, each of whom has his own idiosyncrasies, and looks out on life through his own pair of eyes, with his own ambitions, and his own hopes and fears. Some workers are intensely sensitive and timid, others are indifferent or callous; some have heavy burdens of anxiety at home, others are reckless free-lances. Now, I do not think that the employer, as such, is responsible for the welfare of the workers in matters which are not directly concerned with factory conditions. He has no right to spy upon their private lives, or to interfere with their liberty outside working hours. But he is absolutely responsible for treating them in accordance with the claims of citizenship and of human personality while they are in the factory.

What does this involve? It involves a definite effort on the part of employers to see that the worthy ambitions of every worker are fostered and encouraged. It involves the selection of managers and overlookers who have the power of leadership and inspiration, and the ruthless dismissal from posts of responsibility of the man who can only secure his ends by bullying. From the moment workers enter our factories, we should let them know that we desire their welfare as well as our own profits. We should lose no opportunity of giving encouragement and praise where these are due, and when blame or reprimand is called for it should be administered with justice and dignity. Due regard should always be paid to the individuality of the worker. Education, the drawing forth of the best that men or women have to give, should be the keynote of our methods. I think that if we keep this ideal before us the status of the worker will inevitably alter. The term "wage slave" may often be used by the

SOCIAL OBLIGATIONS OF INDUSTRY

workers in bitter exaggeration of facts. But we should give them no excuse for using it at all. In the future they should be increasingly regarded as co-operators with the employer in the work of production, and they should share in the control of the business on its industrial side, as contrasted with its commercial and financial side. The present movement towards the creation of Whitley Councils is, I believe, entirely sound. There is scope for much experiment in the direction of giving the worker more and more responsibility, in connection with the maintenance of discipline and the determination of working conditions. Some bold experiments have already been made in this direction, with promising results. We must move cautiously, for any approach to anarchy or lack of discipline in a factory is fatal to efficiency. But we must not take fear for our guide. I look forward to a time, not far distant, when employers will give rein to their natural sympathy, and shake themselves free from the ruts of outworn industrial methods, and obsolete conceptions of the relations between Capital and Labour. Then a new relationship will arise between them and the workers, in which both will strive towards greater efficiency whole-heartedly, without the fear of "secret diplomacy" on either side. Employers will acknowledge fully and frankly the rights, the aspirations, and the needs of the workers; while the workers will realise more completely the responsibilities and the difficulties of employers.

Industry, in the future, will make more comprehensive claims on managers and employers than it has ever done before. It will claim from them, not only technical skill and a highly developed power of organisation and administration, but insight, leadership, a profound sense of justice, and broad human sympathy with the whole body of workers.

**THE APPLICATIONS OF PSYCHOLOGY
TO INDUSTRY**

The Applications of Psychology to Industry

BY T. H. PEAR, M.A., B.Sc.

A LECTURE GIVEN ON TUESDAY, NOVEMBER 26, 1918
(WITH SUBSEQUENT ADDITIONS)

THE AIMS AND SCOPE OF MODERN PSYCHOLOGY

IT may be permissible, in a lecture of this kind, to begin by stating what is meant by the term 'psychology.'

Any definition of psychology may be regarded by us simply as a boundary laid down to confine our activities within reasonable limits. It has been said that, as sciences progress, they tend to smudge their own border-lines. We shall interpret our description of psychology in this spirit.

The definition which will be proposed describes psychology as the *positive science of mental processes*. It will be profitable, before we turn to the more concrete material of this lecture, to consider some of the terms employed in this definition. First of all, why is psychology called a *science*?

It is fairly generally accepted that science is distinguished from other studies rather by its method than by its material. In this sense we may admit the validity of the description of science as organised and systematised knowledge of facts. Wherever we can obtain facts and can arrange our knowledge about them into ordered systems, enabling us to understand their inter-relation, there we have a science. The claim of psychology, like the claim of any other study, to the title of a science, is

APPLICATIONS OF PSYCHOLOGY

ultimately dependent upon the data which it uses and the methods which it adopts in order to deal with these data.

PSYCHOLOGY AND COMMON-SENSE

It is sometimes urged that much of what is nowadays called psychology is merely common-sense. In a way, this is partly true, but it should be scarcely necessary to point out that, even if this be so, organised common-sense is preferable to the unorganised variety. However, there are several other reasons why psychology cannot be identified with common-sense.

First of all, common-sense does not always give us a knowledge of *facts*, *e.g.* it tells us that the sun moves round the earth. Indeed, much of the 'sense' of modern science is extraordinarily *un*common. Secondly, even common-sense which is in strict accord with the facts usually varies enormously in extent with the individual possessing it, is seldom the property of all people, or of all peoples, and, moreover, all through history has often been jealously guarded from others as a craft-skill. Thirdly, the common-sense possessed by different individuals obviously increases enormously in power and value when the facts emanating from widely different sources are welded together into a system, so that the relations between them may be grasped and the greater conceptions thus formed may lead to the discovery of new facts. Lastly, much of the common-sense of any generation is merely the science of the preceding one.

As an illustration of these reflections, we may suppose—and we shall not go far wrong in making this assumption—that it has been a common-sense belief that longer hours of work imply increased output. Like many common-sense beliefs, it is often true. Yet, as we know nowadays, it is not seldom untrue, as in the following instances :

APPLICATIONS OF PSYCHOLOGY

In a certain munitions factory, the interpolation of a fifteen-minutes' rest in each hour is reported to have yielded a definite increase in the output of work, despite the initial objection of the men, who were being paid by piece-work.¹

In a bicycle-ball factory in the United States, the work of eliminating defective balls was performed by girls whose working hours were shortened in successive steps from 10½ hours per day to 10, 9½, 9, and 8½ (the pay per day remaining the same). With each shortening of the working day, the output increased instead of diminishing.²

Now it is clear that these isolated instances, while adding to our stock of facts, enrich very little our scientific knowledge. We should require to filter out the physical and mental factors, such as freshness, interest, good-will, fatigue, and boredom, which lead not only to the above results, but to many similar and dissimilar ones, before we could arrive at any knowledge worthy of being called scientific. And such a disentangling of the complicated factors which co-operate to bring about such a result is possible only to the trained observer, fully cognisant not only of the industrial aspect of the problem, but also of its physiological and psychological sides. Such observers at present are very rare; they are urgently needed; and the functions of our universities should be to assist the industries in training them, probably in specially designed institutes.³ As Mr. F. W. Taylor says :

What we are all looking for . . . is the ready-made competent man, the man whom some one else has trained. It is only when we fully realise that our duty, as well as our opportunity, lies in systematically co-operating to train and make this competent man, instead of hunting for a man whom some one else has trained, that we shall be on the road to national efficiency.⁴

¹ C. S. Myers, *Present-day Applications of Psychology*, London, 1918, p. 15. (Quoted from *Interim Report on Industrial Efficiency and Fatigue*, Ministry of Munitions, 1917, pp. 10, 16.)

² F. W. Taylor, *The Principles of Scientific Management*, London, 1911, pp. 86-97.

³ Cf. Lieut.-Colonel C. S. Myers's practical suggestion, *op. cit.*

⁴ *Op. cit.* p. 6.

APPLICATIONS OF PSYCHOLOGY

SOME PROBLEMS FOR PSYCHOLOGICAL INVESTIGATION

Let us now consider some industrial problems which can be attacked by the methods of psychology. We will first attempt to compile a rough list of some different aspects from which industrial activity may be regarded. No attempt has been made here to put them into any arrangement approximating to an order of merit; the very condition of the list may serve as a reminder of the preliminary nature of the analysis.

DIFFERENT ASPECTS FROM WHICH WORK MAY BE REGARDED

1. Initial capacity of the individual worker before training :
 - (a) physical,
 - (b) mental.
2. Method of work :
 - (a) involving improvement of tools, machinery, etc.,
 - (b) involving modification of the physical and mental processes employed by the worker.
3. The 'will to work.'
4. Energy expended.
5. Output :
 - (a) quality,
 - (b) quantity.
6. Wages :
 - (a) amount,
 - (b) conditions determining their payment.
7. Periods of work :
 - (a) total length,
 - (b) the manner of their distribution.

In any scientific discussion of the means by which output may be increased without detriment to the worker and with profit both to the employer and em-

APPLICATIONS OF PSYCHOLOGY

ployed, all the above aspects should be taken into account. Yet it is rare to find such a state of affairs. Discussion usually centres around a few only of these points, *e.g.* 5, 6, and 7 (*a*). We have heard little in this country, for example, of the importance of 1, 2 (*b*), and 7 (*b*). Yet all of them involve psychological factors in that they imply, in one way or another, the necessity of considering the mental processes of the worker.

Now, in attempting to apply psychology to the problems of industry, it is necessary rigidly to distinguish between the best conceivable and the possible. A choice of method now offers itself in the exposition of the rest of this lecture. Either we may consider, first, the best conceivable situation which may be reached, subsequently modifying that picture in accordance with the actual possibilities, or we may attempt the task from the opposite end. This would involve the discussion of those modifications which are practicable to-day, followed by an examination of future possibilities.

These two methods of treatment are well illustrated if we consider the relationship between 1 and 2 in the above table. We may either :

- (*a*) attempt to select the workers who are initially well fitted for the tasks they are about to undertake, subsequently training such selected workers along scientific lines, in order to teach them the best method of work before, and not after, they have learnt other less efficient methods ;
- or (*b*) assuming that the worker is fitted for his present task, we may strive to improve the conditions under which he works, his tools, machinery, and especially his method of working.

It is clear that (*b*) is possible at the present moment. It is equally obvious that to carry out (*a*) under present conditions offers serious difficulties. It is, however, by

APPLICATIONS OF PSYCHOLOGY

no means obvious that course (a) would meet with insuperable difficulties in the case of young workers who had not yet chosen any vocation. As we shall see later, selection might reduce considerably the number of workers who, under present conditions, fail at their task simply because of their initial unfitness to perform it. Furthermore, a person who had failed at his first job would be able to obtain advice as to the next kind of work which he might profitably attempt.

For the purpose of exposition, it will be simpler if we discuss possibility (a) first. Our first subject then becomes :

The selection of workers fitted naturally, or by education, for special tasks.

Every one agrees that a person, in order to become a successful singer, must initially possess an 'ear for music,' or to succeed as the driver of a locomotive, must be able to discriminate between colours. In the latter case, indeed, selective tests have been in use for many years. But the fact is not so generally grasped that such capacities as quick and retentive memory, good muscular control and co-ordination, quickness of judgment, also fit people for special tasks in everyday life. Moreover, such capacities can nowadays be tested and subsequently trained. The great care and thought which is often given to the selection of an athlete for a competition, and to the careful training which he subsequently receives, is seldom equalled when the question is not one of play, but of work.

Now, in what ways would the psychological selection of workers offer advantages over the present system or usage? We may understand this more easily by considering briefly two ways at present in vogue for choosing workers. The first depends upon the general impression made by the candidate upon the representative of the employers. Such a representative is spoken of

APPLICATIONS OF PSYCHOLOGY

by others, and in time, perhaps, comes to describe himself, as a 'judge of men.' It would be interesting to discover the data upon which he forms his judgment, or, alternatively, to learn whether, if he has analysed out such data, he is consciously guided by any of them in his selection. We are referring here not, of course, to the judgment which is based upon the applicant's past record of work, but upon that decision which is arrived at purely upon the basis of naïve personal impression.

Such a decision may in many cases prove to be justified by the subsequent performance of the chosen man ; but in so far as it is merely subjective, and is not based upon objectively verifiable data, it must always be unscientific, and it shares with other unscientific observations the serious drawback that it is impossible to communicate to others. For this reason, the transfer of such a 'judge of men' to another situation inevitably leaves his former employers to begin exactly where they were before he joined their service.

Another method of selecting a worker is to try him upon the actual task which he is to carry out. This seems, at first sight, the common-sense method, for it has the obvious recommendation that the test is made under actual working conditions. Yet it is clear that there are serious drawbacks to this procedure in certain cases, for example, where expensive and delicate machinery is concerned. Not only that, but a failure in such a protracted test is deplorable both for the worker and the employer. The worker is discouraged, and his disappointment is increased considerably by the fact that, having failed at one task, he has learnt nothing which will help him to select another. If the causes of a few hundred such failures had been scientifically analysed and comprehended, it should have been possible to offer him another job in which the particular talent in which he was deficient was not required. Moreover, it is not too much to suppose that often the failure could

APPLICATIONS OF PSYCHOLOGY

have been avoided altogether, in that as a result of selective tests the worker would have been advised not to take up that particular class of work.

Let us now turn to the next possibility, that of applying physiological and psychological tests to those who are about to begin their industrial career.¹ Such tests would be based upon an analysis of the physical and mental characteristics required in these tasks. Clearly, this analysis would be possible only after an actual acquaintance with the task had been made by the investigator.

We may take as an example of the results of such an analysis the tests of operators in the service of the Bell Telephone Company, made by the late Professor Münsterberg of Harvard University.

As the company employs 16,000 operators, the problem is an expansive one. . . . Every girl who satisfies the entrance conditions . . . receives some salary throughout the months of training in the telephone school. Since during the first half-year, in which the employee still works entirely under supervision, more than a third of those who had originally entered leave, partly on account of over-fatigue or similar reasons, the economic disadvantage to the company is evidently a very great one. The candidates are paid for months of mere training, and they themselves waste their energy and time with practice in a kind of labour which cannot be serviceable to them in any other economic activity. Under these circumstances it is not surprising that one city system approached me with the question whether it would not interest me from a scientific point of view to examine how far the mental fitness of the employees could be determined beforehand through experimental means.²

Münsterberg, concluding, after an analysis of the actual activity at the switch-board, that the most important mental capacities involved were memory,

¹ It should be obvious that a worker is unlikely to make a brilliant success of any task for which (although he may be initially fitted for it) he has no desire. Desire for work must go hand in hand with capacity for work. The object of the tests should be simply to give advice to those who wish for it.

² *Psychology and Industrial Efficiency*, London, 1913, pp. 99-115.

APPLICATIONS OF PSYCHOLOGY

attention, intelligence, exactitude and rapidity of movement, tested, with reference to these capacities, thirty young women who a short time before had entered the telephone training school. He calculated the grade (*i.e.* order of merit) of each girl for each achievement, and finally took the average of all the grades as the expression of the experimental result.

With this average rank-list, we compared the practical results of the telephone company after three months had passed. These three months had been sufficient to secure at least a certain discrimination between the best, the average, and the unfit. The result of this comparison was on the whole satisfactory. First the sceptical telephone company had mixed with the class a number of women who had been in the service for a long while, and had even been selected as teachers in the telephone school. I did not know, in figuring out the results, which of the participants in the experiments these particularly gifted outsiders were. If the psychological experiments had brought the result that these individuals who stood so high in the estimation of the telephone company ranked low in the laboratory experiment, it would have reflected strongly on the reliability of the laboratory method. The results showed, on the contrary, that these women who had proved most able in practical service stood at the top of our list. Correspondingly, those who stood the lowest in our psychological rank-list had in the meantime been found unfit in practical service, and had either left the company of their own accord or else had been eliminated. The agreement, to be sure, was not a perfect one. One of the list of women stood rather low in the psychological list, while the office reported that so far she had done fair work in the service, and two others to whom the psychological laboratory gave a good testimonial were considered by the telephone office as only fair.

These tests were made before 1913, and it is possible, in the light of more recent knowledge, to improve upon their technique. An important feature of Professor Münsterberg's procedure was that he compared his findings with the results of selection produced by the three months' actual experience of the same workers. In this way there is left no room for the suspicion that,

APPLICATIONS OF PSYCHOLOGY

interesting as the psychologist's results may be, they are not susceptible of verification. The orders of merit drawn up as a result of the psychological tests and of the three months' actual test respectively showed a high degree of resemblance.

Nowadays, however, we need not rest content with such a vague statement. The degree of resemblance between the orders of merit in two lists containing the same names can be accurately measured, and expressed mathematically as a 'coefficient of correlation.' In terms of this coefficient, perfect direct relation or identity between the lists is expressed by the number $+1$. Perfect inverse relation (*i.e.* the case in which one list is the simple inversion of the order of the other) is represented by -1 . An absence of any correlation between the orders in the lists corresponds to the coefficient zero.¹ This would represent the case in which there was nothing whatever in common between the psychologist's tests and the test of actual experience. It is therefore possible nowadays to test the results of the psychological examination by mathematical means.

To a certain extent we may regard the above investigations as attempting to test, in a very general way, certain capacities of mind, such as memory, intelligence, and attention. There is, however, another branch of this subject, of equal importance—the testing of *specialised* mental capacities. The investigations of the last thirty years have shown that an individual may possess extraordinarily developed mental capacities, which, at the same time, are very narrowly limited. Such a person may be invaluable in one particular niche in the industrial structure, but unless his particular ability is discovered, accidentally or systematically, his special talent may lie buried all through his life.

Interesting examples of these specialised capacities

¹ For an introduction to the theory of correlation, see Elderton's *Primer of Statistics* (London, 1912).

APPLICATIONS OF PSYCHOLOGY

have been given by Muscio.¹ We may comment upon some of them here.

1. *The 'Span of Memory.'*—As is well known, people differ considerably in their ability to keep in their head for a short time, after seeing or hearing them, a number of figures, words, or commands. These differences have long been the subject of experimental inquiry in psychological laboratories. It may surprise the reader to learn that in one such investigation a person was discovered who could repeat 40 disconnected numerals, after having seen them exhibited upon a screen for one second. Another subject was able to repeat almost as many. This long span of memory must be of use in many industries. In fact, it has been shown to be one of the chief factors affecting the working speed of a well-known type-setting machine. It is not in their quickness of movement in which individuals differ so much as in their ability to remember a large amount of their material after one glance at the copy. The reduction of the number of times in which the operator looks away to his copy enormously quickens his rate of output.² It is probable again that a long memory span would be extremely useful to the typist, the wireless operator, and to many others engaged in similar occupations.

2. *The 'Rate of Perception.'*—Muscio points out a common experience which many have had in the kinematograph theatre, viz. the feeling that the explanatory verbal matter, exhibited to connect the various parts of the story, remained upon the screen for too long a time. Others in the theatre may have felt that the time was too short. Presumably those responsible for deciding the length of exposure have tried to strike an average of different persons' powers in this respect, and then to exceed that average by a generous amount. There exist

¹ *Lectures on Industrial Psychology*, Sydney, 1917, p. 96 f.

² Münsterberg, *op. cit.* p. 124.

APPLICATIONS OF PSYCHOLOGY

important differences in this rapidity of visual perception, as it may be crudely termed.

This point can be brought out in another way. Muscio found experimentally that when a kinematograph film was exposed for a given time to different persons (all University graduates and undergraduates, including both men and women), some were able to report having seen three times as many items as others. We may suppose that if such a range of difference is demonstrable in a selected sample of the population, it will be still wider in a more representative collection.

3. *General Muscular Capacity*.—It is common knowledge that there exist people who learn easily and quickly many kinds of performances in which the delicate 'timing' and co-ordination of different muscle groups is essential. Such happy persons seem to glide easily into the technique of swimming, dancing, fencing, typewriting, or playing a musical instrument. Their intelligence may or may not assist them in acquiring such skill. In fact, it is notoriously true that many highly intelligent persons find the topmost flights of such muscular performances beyond them, however much they may try. Modern psychology offers reasons for such success and failure. Prominent among these is the fact that such performances involve what is known as motor imagery: the capacity to call up in the mind the memory of previous movements: to feel them in the mind's muscles, we may say, in contradistinction to 'seeing them in the mind's eye.' A man with well-developed visual imagery and with poor motor imagery may learn to play golf or to dance fairly well; but he will learn slowly and painfully, and probably he will never become a first-class performer. He will experience these limitations, because although he remembers where to put his limbs, he does so in his mind's eye. He visualises their position and then places them there. The possessor of well-developed motor imagery, on the

APPLICATIONS OF PSYCHOLOGY

other hand, remembers the movement in his muscles, in the exact 'language' in which it reached him, when he originally experienced it. He does not need to translate his visual memory into muscular terms, and thus can avoid the depreciation which such translation would inevitably involve.

We easily see, therefore, the benefits which would follow from a selection of the naturally motor-minded person. It is not impossible that such a selection would make clear to the candidate the sphere of work in which his talents would be best employed, and save him from possible failures in other directions.

4. *Quickness of Reaction*.—An important capacity, and one which also shows significant individual differences in different persons, is the ability to act promptly when the meaning of a certain situation is grasped. In its simplest form, this may involve nothing more than pressing a button or moving a lever when some simple change in the field of vision or hearing occurs. A more complex form of reaction involves the quick apprehension of the meaning of a situation and the making of the one right response out of numerous possible ones. The first is called a 'simple' reaction, while the second is technically known as a 'choice' reaction. Both kinds have been extensively studied in physiological and psychological laboratories.

In our own country, visual, auditory, and tactual reaction times have formed some of the tests in the selection of candidates for the Royal Air Force.¹ Slowness of appropriate reaction, or a tendency to wrong reaction, is incompatible with success as a fighting aviator.

5. *Type of Attention*.—To say nowadays that a person's power of attention is good or poor, is to make a very vague and general statement, which may prove to be of little practical use. For the manifold tasks to which one may be required to attend in the course of a

¹ Cf. the *Lancet*, March 16, 1918, p. 399. Also Myers, *op. cit.* p. 23.

APPLICATIONS OF PSYCHOLOGY

day may demand quite different kinds of attention. Of these kinds we may select here for brief mention two, the 'spread' and the 'concentrated.'

An excellent example of an activity demanding continuous 'spread' attention is that of driving a motor-car through dense traffic. A first-class driver will notice approaching objects, the direction and pace of vehicles or pedestrians crossing his path, making quite easily all the appropriate reactions to them, while all the time he may be conversing fluently with the passenger at his elbow. If necessary, at any moment his attention can be momentarily concentrated upon one object in his field of vision, but it is normally spread over all the possible objects.

A somewhat similar state of affairs probably exists in the case of a person watching many threads in a machine in order instantaneously to detect and rectify breakages.

Compare this with the observer of some minute variety of insect life. His attention must be concentrated, perhaps for hours together, upon the changes occurring in just one part only of his visual field. It is quite possible that there are industrial processes requiring such concentrated attention, and that the knowledge of the possession by a worker of such powers would be of great value both to him and to his employer.

It is probably going too far beyond the boundaries of verified fact to say that these two types commonly exist distinct from each other. Yet the fact that some people seem to be able to apprehend a number of varied events occurring simultaneously—*i.e.* to spread their attention—while others seem able only to attend efficiently to some relatively restricted occurrence, suggests this possibility.¹

¹ Cf. Fleming and Pearce, *Principles of Apprentice Training*, London, 1916. In their list of characteristics desirable for the artisan, they include the "instinct for appraising a number of conditions conjointly." Münsterberg's tests of the drivers of electric trams took into account the same characteristic.

APPLICATIONS OF PSYCHOLOGY

We may now pass from the consideration of the personal characteristics of the worker to that of the conditions of his work.

The Best Conditions of Work

Any attempt to reach the ideal of perfect working conditions must be based upon a clear realisation of their twofold nature. Working conditions may be divided into those which are external to the worker and those which obtain inside the worker's own body or mind. Typical of the first class are such objective determinants of good work as ventilation, temperature, humidity, illumination, absence of glare, of noise, of vibration, or of dust, proper food, seats or benches allowing of the adoption of the correct bodily attitude at work, length of hours, and length, number, nature, and distribution of rest-pauses. Improvements in all these, however, are often much more easily achieved than the second class of improvements, those which lead to the adoption of the *best method* of work. The reason is obvious, for, as Taylor has pointed out, while every one, if he wishes, can appreciate the waste of material things, of coal, water, or forests, the enormous wastage of energy due to awkward, inefficient, ill-directed, needless, or needlessly repeated movements requires for its understanding an effort of the imagination. He might perhaps have added that while any such effort is difficult enough for most people, this particular variety is rendered harder than ever because of the fact that most of us consider our own way of working to be the best, and therefore resist strenuously any attempt to inquire into its nature. Such investigations, however, carried out by Taylor and Gilbreth, by means of apparatus which renders flights of imagination unnecessary, have resulted in discoveries the nature of which can only be described as startling. We shall discuss them later.

Among the subjective conditions affecting work,

APPLICATIONS OF PSYCHOLOGY

none have come into public notice more prominently than that of *fatigue*. Indeed, for many investigators the word 'fatigue' has now become a convenient label for a whole number of goals towards which their work is tending. Under the title 'fatigue investigations,' for example, we now find inquiries into a host of conditions, prominent among which are length of hours, rest, and recuperation.¹ The British Association Committee on Fatigue and the Industrial Fatigue Research Board are both carrying out such many-sided investigations.

It may, however, be asked, 'In what ways are the psychological aspects of work implicated in such fatigue-study?' To answer this question would require a whole volume, but an indication of the lines along which such a reply might be framed will be attempted here.

Of first importance is the realisation that fatigue and weariness are by no means the same thing. If, following Rivers,² we define fatigue as "a condition of lowered capacity for work which follows, or occurs during, the performance of work of which it is the direct result," it can easily be demonstrated that fatigue may exist without weariness, and *vice versa*, while, though they often coexist, it is always unsafe to assume any complete parallelism between them.

Weariness may be described as the consciousness of fatigue, or 'subjective' fatigue in contradistinction to the 'objective' fatigue which we have just defined. Now Rivers has shown that, "in the performance of mental work especially, decided sensations of fatigue may be experienced when the objective record shows that increasing and not decreasing amounts of work are being done; and there may be complete absence of any sensations of fatigue when the objective record shows that

¹ Cf. P. S. Florence, "The Use of Factory Statistics in the Investigation of Industrial Fatigue," 1918, *Columbia University Studies in History, Economics, and Public Law*, vol. lxxxi. No. 3 (Whole Number 190).

² *The Influence of Alcohol and other Drugs upon Fatigue*, London, 1908, p. 2.

APPLICATIONS OF PSYCHOLOGY

the work is falling off in quality, or in quantity, or in both."¹ Moreover, it has been shown that mental weariness of an unusual degree may coexist with a supernormal muscular performance.²

Finally, it is probably necessary to distinguish between subjective fatigue and boredom. The man who, though completely uninterested in card-playing, takes a hand for politeness' sake, may be bored in a few minutes, while as yet he can be suffering neither from objective nor from subjective fatigue. In such strenuous activities as tennis or dancing, it is not uncommon for us to feel both objective and subjective fatigue without the slightest trace of boredom. Experiment shows very clearly how untrustworthy are the worker's own feelings if taken alone as the indication of a lowered or increased capacity for work.

Again, the combating of fatigue by means of rest-pauses raises psychological questions at all points. Once more it has been shown that subjective feelings are a very unsafe guide in this field, and that not only the total length of the pause or pauses, but also their number, their distribution throughout the days' work, and especially the nature of the rest taken in them are enormously important factors. This appears more clearly when we inquire into the purpose of the rest-pause. It is to decrease fatigue, and if possible to banish it entirely. But a rest-pause which is too long, while achieving this result, will also allow to vanish some of those favourable conditions which have been set up in the worker by the very continuance of the work itself. These favourable conditions, again, can be fully appreciated only as the result of psychological study. Chief among them are 'warming-up' or incitement, 'settlement', practice, and the appreciation of the nature and magnitude of the task to be performed.

'Warming-up' is a process familiar to all workers.

¹ Rivers, *loc. cit.*

² *Op. cit.* p. 104 f.

APPLICATIONS OF PSYCHOLOGY

It consists in an overcoming of the initial inertia, which most people feel on commencing work, a victory which is usually achieved by the rapid tapping of any sources of enthusiasm which the worker possesses. Its effects are particularly observable in factories and schools on Monday mornings, and in universities during the first week of the term. Any interruption soon after the first warming-up has been achieved may have disastrous effects. Being called to the telephone at this stage of a morning's writing may mean the spoiling of half-a-day's good work.

Upon this stage, however, there usually supervenes that of 'settlement' or 'settling-down.' The worker gradually slips into a condition in which he becomes relatively immune to both external and internal distractions. The traffic, the movements of people in the room, the insistent tugs at his mind of its own memories, worries, and ambitions, these all become ignored as, settling down comfortably into his stride, he becomes carried along by the work. A brief interruption at this stage may have little effect upon him, for it cannot stand against the momentum of his main stream of interest. A rest-pause here would obviously be injudicious; the worker, not yet fatigued, would simply risk the loss of what he would probably call the 'swing of his work.'

The provision of rest-pauses, therefore, is clearly a problem to be solved only upon the basis of knowledge concerning the special work in question. Two striking examples of the beneficial effect of scientifically interpolating rest-pauses may be given here :

In the Bethlehem Steel Company, the employers were desirous of increasing the rate at which pig-iron was handled by their men. At this time the average amount handled by each man per day was $12\frac{1}{2}$ tons. It was anticipated that the introduction of piece-work at higher wages might possibly increase this amount to 18 or 25 tons per day. But an investigation was carried out

APPLICATIONS OF PSYCHOLOGY

in which the loads carried and the time taken for rest were carefully examined, with the object of finding the most advantageous distribution of work and rest. The result of the application of this discovery to the conditions of work was that the men carried, on the average, $47\frac{1}{2}$ tons without greater fatigue. Their wages were raised by 60 per cent.¹

A remarkable case of decrease of fatigue owing to a change in the arrangement of rest-periods is given by Mrs. Clark and Miss Wyatt in their study of women workers. The girls employed on rather monotonous work in a bleachery had been allowed two periods of three-quarter-hour rest in the day, besides their dinner-time of three-quarters of an hour. Under Mr. H. L. Gantt's management, they were given spells of 1 hour 20 minutes' work, 20 minutes' rest, throughout the working-day, with an arrangement of 'spare hands,' which obviated any break in the work of the machines. The girls' output was increased about 60 per cent, and they were able to earn about 50 per cent more wages.

The authors observe that in another part of the factory the girls were allowed to choose their rest-periods, and chose two long ones, during which they usually did fancy-work. The result was not as satisfactory.²

Running parallel, however, with all these lines of reform is still another, which in late years has attained such prominence that it is often spoken of by the special name of *Motion Study*. Its purpose can easily be stated. While the improvements we have considered above have aimed at ameliorating the conditions under which a person works, motion study improves the method of work itself. Its aims are, by a detailed study of the human movements customary in any industrial process, first, to divide such movements into essential and unessential elements; secondly, to eliminate the latter; thirdly, to improve the essential elements; and, fourthly, to recombine them into a more efficient method of procedure.

Since the time taken to perform these elementary motions is always considered, the whole investigation is

¹ F. W. Taylor, *Principles of Scientific Management*, New York, 1911, p. 58.

² M. and A. D. McKillop, *Efficiency Methods*, London, 1917, p. 102.

APPLICATIONS OF PSYCHOLOGY

sometimes known as Time and Motion Study. Numerous examples of such studies are to be found in the books by Taylor, the Gilbreths, the McKillops, and others. We may select two here :

Mr. F. B. Gilbreth "saw a girl-worker at one of the Industrial Exhibitions in London putting paper-covers on small round boxes filled with polishing material. She was pointed out as an unusually rapid worker ; he timed her as doing 24 boxes in 40 seconds. He ventured to suggest to her a new disposition of the material and motions, which she tried with much scepticism. At the first attempt she did the 24 boxes in 26 seconds ; at the second attempt in 20 seconds, and she was not, she admitted, 'working any harder.' " ¹

The same investigator studied scientifically the process of assembling the various parts of the base of a machine for manufacturing braid. Before the work was rearranged, the parts had always been put together in a more or less haphazard order. The result of study was to make more convenient the size and height of the bench on which the parts were to be assembled, to provide a more convenient resting-place for the tools and parts, so that when they were required they could be picked up 'automatically,' to shorten the path of the hands when loaded, and to arrange the parts in the sequence in which they could be fitted most conveniently to the base. These latter aims were achieved by the use of a holder or 'packet,' on which the various parts were fixed in such a position that their transporting distance should be as short as possible. Before this investigation, a good day's output for one man had been considered to be 18 base groups. By the new method, each man easily assembled 66 with no greater fatigue.

While in the earlier investigations a stop-watch was used as the time-measurer, instruments of greater precision have, for many investigators, now superseded it.

¹ McKillop, *op. cit.* p. 92.

APPLICATIONS OF PSYCHOLOGY

Extensive use is now made of the cyclegraph,¹ a small electric light, which can be attached to the tool the movement of which is being studied, or to any part of the limbs of the worker. When photographed, this light leaves a continuous trace on the film, indicating clearly the path of the movement. Its duration is made visible by including in the electric-lamp circuit an interrupter of known period, so that the line appears as a series of dashes. Slow and fast movements will thus be clearly comparable by the eye, since the former will leave short and the latter long dashes. By arranging that at each illumination of the lamp the incandescence of the filament shall be completed quickly and die away slowly, the dashes will appear broadest at their hinder (earlier) end, tailing off to a point at their foremost (later) end, thus resembling arrow-heads and indicating the 'sense' of the motion. Finally, the absolute direction in space of each motion is studied by stereoscopically photographing the movement. From such a stereoscopic photograph a wire model can be constructed, giving the path of the motion in three dimensions, and painted in white and grey to represent the 'arrow-heads.'

The advantages, for teaching purposes, of such a model are obvious, for it can be examined from any angle, whereas the photograph represents the path of the movement only from the angle at which it was originally taken. The kinematograph is also utilised in combination with the cyclegraph. By taking a very large number of pictures of a movement in a short time, it is possible later to study the movement kinematically when the film is run through the machine at a slower rate.

The cyclegraph shows very strikingly the precision of a good worker. When he makes a movement re-

¹ For description and photographs, see Gilbreth, *Motion Study*, New York, 1911, *Fatigue Study*, London, 1916, *Applied Motion Study*, London, 1919.

APPLICATIONS OF PSYCHOLOGY

peatedly, the paths described in the photograph are almost identical.

It is useful to summarise from the results of the present work on motion study those lessons which are of importance because of their physiological or psychological significance.

(1) Wherever possible, use is made of related muscle groups. In typewriting, the expert uses all, or nearly all, his fingers; in bricklaying, by the improved method, both hands are employed.

(2) The right method should be taught from the first. In this way the necessity of unlearning bad habits—usually a very lengthy process—is obviated.

(3) The movements made in performing work slowly, occupy paths entirely different from those made in the rapid performance of the same task. In teaching, therefore, the right method must be taught where possible at the standard speed, not at an artificial slow speed which is later accelerated.

(4) The teacher should teach the actual movements which the learner is expected to perform. Gilbreth claims that under present circumstances the methods taught to a learner are often quite different from those which the teacher himself uses when working at his customary speed.¹

(5) All unnecessary acts of decision should be eliminated, thus saving time and mental energy.

(6) Rest-pauses should be introduced at the proper places.

(7) Practice in any series of movements, in order to be effective, should be *specific*, not general. This fact, clearly recognised in athletics for many years, is by no means generally understood in the world of work.

(8) The consciousness that a definite task is to be performed, and can be performed in a definite time, has

¹ Mr. Filson Young's description (in *New Leaves*) of a certain teacher of golf is interesting in this connection.

APPLICATIONS OF PSYCHOLOGY

a stimulating effect upon the worker. Conversely, a known impossibility of accomplishing the task has a depressing effect, which is reflected in the results of his work.

(9) The tendency for the old, bad habit of doing work wrongly, to assert itself after the first flush of interest in the new method has vanished, is anticipated and guarded against.

(10) The importance of *incentive* is appreciated both in the way in which remuneration is arranged for and in the direction of interesting the worker in and encouraging him to contribute to improvements effected.

(11) This new study brings with it a realisation of the *resemblances* between what at first sight appear to be entirely different spheres of work. Many motions are common to different activities, not only in the same branch, but also in different branches of industry. The benefits of a discovery may therefore irradiate into quite unexpected fields, and principles enunciated for one industry may prove to be applicable, with but a few modifications, to others.

Lack of time alone has brought it about that nothing has been said in this lecture of the applications of psychology to such specific problems as that of salesmanship and advertising, or to such general questions as the social relations, both between workers themselves and between them and their employers. Its sole aim has been to attempt to demonstrate the importance of the conservation of human energy and to arouse interest in the ideal of its direction into channels most likely to increase human happiness.

**EDUCATION AS A FUNCTION OF
MANAGEMENT**

Education as a Function of Management

By A. E. BERRIMAN, O.B.E., M.I.MECH.E.

A LECTURE GIVEN ON TUESDAY, 4TH FEBRUARY, 1919

PART I

THE APPRENTICE MASTER

1. **T**HE premiss of this lecture is that education is a function of management.

2. If you conceive Industrial enterprises to be pyramids of human activity directed from the apex through successive grades of executive control, then the management is responsible for securing for its organisation the elements of a common nature, in order that it may enjoy the corporate existence that is essential to individual happiness and to collective efficiency.

3. At the base of the pyramid, Industrial Education concerns itself with such questions as schooling and apprenticeship; higher up it is related to the development of personnel already educated to the University standard of thought and learning. At every stage and for every class, however, the education should possess three qualities:

- i. Humanistic, to secure general happiness.
- ii. Technical, to secure collective efficiency.
- iii. Evolutionary, to secure individual development.

4. This threefold interest covers such a wide field that its actual operation must be the concern of a specialist. In short, management will fulfil its educa-

EDUCATION AND MANAGEMENT

tional function best by making an appropriate appointment to the staff.

5. The questions that at once arise are :

- (a) What is to be the exact position of the educationist in Industry ?
- (b) What are the special qualities that he should possess ?

6. The needs of various branches of Industry doubtless differ in detail, but it is probable that they have broad requirements in common, and may thus to some extent be typified by Engineering, to which the following remarks more particularly relate.

7. In the Engineering Industry there is a growing opinion in favour of appointing a member of the staff to have a particular and recognised official interest in the well-being of juvenile labour. In some cases he is known as a Welfare Supervisor, in others he is termed an Apprentice Master; the latter term seems more appropriate to the work, but the title is, naturally, of less consequence than the utility of the service rendered, and it is to this aspect of the subject that the present paper is addressed.

8. There is, however, this point of importance about the question of title : if the Apprentice Master is required to regard his interest in the firm's broad educational plans from the principles previously enumerated in respect to the Humanistic, Technical, and Evolutionary purposes of education, it is apparent that the organised recreation and social life more commonly associated with the term "Welfare" represent only one phase of his work. In relation to the scheme as a whole, Welfare might appropriately be described as the "Applied Humanities" branch, and as such it is not only essential in itself, but must necessarily be co-ordinated with the general and technical education. Thus associated it plays, potentially, a most important part in enlarging education's evolutionary function by

EDUCATION AND MANAGEMENT

assisting the boy to develop those all-round qualities of character and ability on which his ultimate capacity to succeed in positions of higher responsibility so much depends.

9. Further consideration of these broad issues also shows the need for some scheme or focus of aim possessing a natural tendency to co-ordinate the various aspects of the educational problem, and the principle of Apprenticeship is definitely put forward in this connection. The title Apprentice Master thus has a particular significance, but it is important to avoid any inference that would lead to the idea that the Apprentice Master's sphere of interest is necessarily limited to those who are specifically apprentices. He must essentially be concerned with the education of all the boys in the establishment, and it would be in the natural order of things for his sphere to extend to adult education also, because one part of his practical service to management lies in his power to assist in the selection of the right man for the job whenever there is a vacancy.

10. Good management has always depended on the proper selection of personnel, and, in the future, it will depend on this factor more than it has done in the past, because the shortening of the hours and raising of the wages of labour will require a higher standard of efficiency in every position of responsibility, and a correspondingly increased importance attaches to the avoidance of wrong appointments.

11. The Apprentice Master's job is, therefore, not only to help each boy to make the most of his capacity and to promote as much general happiness as possible, but also to assist the management in regard to the filling of vacancies. His object is not merely welfare, and the degree to which the boys under his care fail to establish themselves on a secure basis of self-supporting manhood is the degree to which he fails in the accomplishment of the major part of his task, notwithstanding that

EDUCATION AND MANAGEMENT

he may have given the lads a very good time whilst they were boys.

12. It is from this point of view that the term Apprentice Master derives its full significance in the title attached to the post.. In order to be successful in respect to the economic side of the boys' welfare, it is essential that the supervisor should be able to count upon a continuous period of interest, and this can only be assured by the principle of Apprenticeship.

13. The Apprenticeship of the future should essentially be regarded as a tri-party moral agreement :

- (a) On the part of the boy to stay the course.
- (b) On the part of the master to give education.
- (c) On the part of the parent to give moral and financial support.

From the documentary point of view, it may be desirable to have a legal agreement, or it may be sufficient to maintain a Register of those who have signified their acceptance of the conditions.

14. On such an understanding as the above, it is possible for the Apprentice Master to make plans with reasonable chance of success, and it will, therefore, be natural that he should encourage suitable boys to become Apprentices. Apprenticeship is not on the whole, at present, popular, and its unpopularity is mainly with the parent rather than with the boy. It involves the sacrifice of immediate return for the sake of future stability, and this element of sacrifice, which is present in one form or another with all education, needs to be presented in its proper light to the parents as well as to the boys. It is not the less necessary to the success of Apprenticeship, however, that the Apprentice himself should feel secure from exploitation, whether as regards undue use of his capacity on repetition work, the payment of abnormally low wages, or

EDUCATION AND MANAGEMENT

the absence of reasonable opportunity for personal development.

15. In respect to the first of these safeguards, the Apprentice Master occupies a singularly important, but at the same time a very delicate position, calling for great tact and a very clear-sighted appreciation of Industrial conditions. The question of wages in respect to Apprenticeship is a matter that is determined in part by forces outside the Apprentice Master's control, but in those cases where it is possible for him to exercise an influence he should endeavour to remove the prejudice against Apprenticeship without going to the extremes that are admittedly deleterious to the welfare of youth. In this connection, the suggestion is put forward that the payment of weekly salaries instead of wages based on hourly rates to Apprentices may in some cases provide a basis for solving the complex financial issues that are involved by the "labour" aspect of Apprenticeship. The field of encouragement for the development of personal capacity is, of course, the Apprentice Master's own particular sphere, and leads more or less directly to the special qualities that he should possess.

16. Naturally, in view of the varying conditions in different places, it is not possible to give a strict definition of suitability, and the object of the present paper is less to define either the sphere or the capabilities of the Apprentice Master than to indicate the existence and nature of his realm, and to suggest that it possesses the elements of a life's interest to men of high calibre. It is not merely a sink for failures in other fields of work, and it would be a grave pity if it should in any sense become associated with such an idea. The Apprentice Master must not be identified with the schoolmaster out of his natural element, nor with the technologist who has failed to make good in his profession. It is a realm of its own, and if the premiss of this paper is in fact true, then the Apprentice Master's job is a post of

EDUCATION AND MANAGEMENT

potential distinction and great importance in Industry, for which men of the highest qualifications will be required.

17. It is, of course, self-evident that they must be men of personality such as to win the confidence not only of the boys themselves, but of the managers, superintendents, and men in the works, for unless this favourable condition is established, the Apprentice Master is only too likely to be regarded as an interloper and a nuisance. The class of boy with whom he will have to deal varies in different works, as also will the character of his own chief occupation. In some localities he may find excellent educational facilities on the spot, while in another he may have to start a school inside the Works. Or again, in one place, he may find recreation in abundance, while in another he will requisition for a games-ground or gymnasium. In either case he will have to play a leading part in popularising the innovation, if it is to be established on a secure basis of future maintenance.

18. Everywhere he will be concerned with the boy's proper training in his trade or profession and in the keeping of a record that will serve the threefold purpose of assisting him to bring each boy's chief qualities into focus, to provide the boy himself with a testamur of real value in his subsequent career, and to advise the management as to the suitability of their own trainees for vacancies as they occur.

19. These various duties all point to the need for an Apprentice Master of broad education, for a man who has supplemented his academic career with an Industrial Pupilage. He must be an educator at heart, and in those firms that admit pupils he may find himself charged with a certain amount of higher scientific and applied mathematical tuition. His job is to turn out capable men, and it is vital to his success that his sphere of interest in the man should not be

EDUCATION AND MANAGEMENT

divorced from a corresponding interest in the man's job itself.

20. It is from this point of view that the suggestion is put forward that the Apprentice Master might perhaps usefully make a special study of applied psychology. It is far too early at present to recommend any general association of Industrial education with this field of work because both are in their infancy. It requires the man and the occasion to make a success of them in double harness, but there would appear to be some justification for coupling these interests if the right class of educationist is brought into Industrial life.

21. With regard to the realm of experimental psychology itself, sufficient proof has already been given of its potential Industrial value to make it a matter of serious interest to management, particularly under the difficult economic conditions of the future. Much time and research has been devoted to the detail of mechanical efficiency, and the results of such labour are in daily application. The factors of human economy, however, are less well known, but there is sufficient evidence to show that it is not less important properly to adjust the conditions of labour to psychological requirements than it is to sharpen cutting-tools to their correct angles and to run machines at their economic speeds.

22. Those who are familiar with the steps of Industrial development are aware how difficult and how laborious was the work of determining the conditions of maximum efficiency for different classes of mechanical work, and it will not be less difficult nor less laborious to arrive at the chief psychological factors of human economy in the different kinds of Industrial enterprise. To approach the subject by direct specialised attack is to expose the attempt to the danger of defeat by natural human reaction against the strange unknown. It has succeeded in certain cases, but is hardly to be recommended in general: firstly, because the subject is

EDUCATION AND MANAGEMENT

too large and complex for instant appreciation; and, secondly, because at present there are few, if any, men competent to attempt such work under such conditions.

23. For some time to come the trained psychologist must be content with other than a direct appointment in Industry, and it is indeed a question whether he may not in any event prefer to retain the direct association with the developing mind that is provided by the educational duties of the Apprentice Master. It is, however, not the purpose of this paper to enlarge upon the theme, but merely to suggest the potential utility of such an association of work. Those interested should read a small book by Dr. Myers, Director of the Psychological Laboratory at Cambridge and some time Consulting Psychologist to the B.E.F., entitled *Present Day Applications of Psychology*. They may also like to know that the author of the work in question is anxious to establish an Association for the collection and dissemination of data.

24. In concluding this part of the lecture, it seems appropriate to recapitulate three salient facts in the present Industrial situation :

- i. The Education Act of 1918.
- ii. Higher wages.
- iii. Shorter hours.

25. Of these, the first can either be regarded as a legal requirement, to be met with the least possible disturbance of existing conditions, or as an opportunity for incorporating education as a function of management and developing its potential service to the utmost. The second and third facts enumerated above are powerful reasons in favour of the second alternative, and they constitute a considerable reason why Industry should at least be interested in the potential association of education with experimental psychology. The field of mechanical efficiency has been well explored, but the realm

EDUCATION AND MANAGEMENT

of human economy is still relatively neglected, and if the changing conditions are to bring increased happiness with increased leisure, it is imperative that we should neglect no field of endeavour that can improve the economy of our working hours.

PART II

APPRENTICESHIP

1. Thus far, this lecture has been devoted to the Apprentice Master as the medium through whom management exercises its educational function, but emphasis has also been laid on the importance of providing some definite scheme of work, and the principle of Apprenticeship has been put forward in this connection. It seems appropriate, therefore, to devote a little time to the history of this once national institution.

2. Child labour has always been an important factor in Social Economy, and by the thirteenth century in England Apprenticeship had become a not uncommon feature of its employment. Industry then, and for many centuries afterwards, was essentially an occupation of Master Craftsmen, with whom it was customary for the Apprentices to reside on terms of social equality with the family, and it was this *in loco parentis* supervision of the child's welfare that undoubtedly conferred on the old-time Apprenticeship a quality that causes its memory to be held in such deservedly high esteem.

3. With Industrial development came the Guilds or Mysteries, which were in London, and often in the larger cities, incorporated by Royal Charter as monopolist companies. They found in their power to regulate the conditions of Apprenticeship a most valuable instrument

EDUCATION AND MANAGEMENT

of fiscal protection, as well as a very efficient means of maintaining the traditional quality of their handicraft.

4. By limiting the number of Apprentices that a master might employ, the Guilds were able to prevent overcrowding, and, while their main purpose in this was probably to avoid undue competition for themselves, its effect was at least as much in the interest of the rising generation; the boys were not only well taught, but they had an almost certain assurance of individual prosperity. So much, indeed, did the system find favour in the public eye that it became compulsory under the Statute of Artificers in 1562, and from that time down to about 1645 it remained a firm-rooted national institution.

5. While the law strengthened the hands of the Guilds, it was they that made it effective, for without the supervision of industry that they maintained by their "Searchers," who regularly visited workshops to inspect the quality of goods and to enquire into the condition of Apprentices, this Act, like many others, would have failed for lack of effective administration.

6. Apprentices under the Elizabethan system served for a period of seven years, and occasionally for as much as ten years when a trade became overcrowded. The signing of Indentures was an invariable custom, but during Apprenticeship no Apprentices were required to pay premiums. Their services were given in return for tuition, board, lodgings, and clothes, and, on the whole, it may fairly be said that the youth of the country was well cared for under the Elizabethan system at its best. It avoided the vitally dangerous break in parental influence, which is one of the chief problems of modern times, and it provided—in addition to a strictly vocational training in the craft—a disciplined social life that stood in good stead of the modern school education. Children and young persons generally in those days were subject to severe, but not unkind, repression, and

EDUCATION AND MANAGEMENT

indeed the interest that the Guilds would take in the seemly cut of their Apprentices' hair—not to mention the fashion of their clothing—must have been very irksome to the adventurous and imitative spirit of youth. It is worthy of interest, too, as marking the power of the Guilds in those days, that they carried out by force the finding of their Courts in such matters, and a too resistant Apprentice would often be clapped into prison.

7. Industrial monopoly was not the only consideration that rendered membership of the Guilds desirable. As a rule, only guildsmen were admitted to the freedom of the borough, which in those days constituted the Parliamentary franchise, and this fact—coupled with the social status that attended it—made the Guild an increasingly important factor in social as well as Industrial life. And as Apprenticeship was, with few exceptions, the only means of gaining admission to the Guild, it is not to be wondered at that it should have become so intimately woven in our English life of the sixteenth and seventeenth centuries.

8. But, in the height of its popularity, it was doomed to receive a staggering blow, from which it never afterwards fully recovered. The Civil War paralysed Industry and rent the social customs of the land, and when, in about the year 1645, Industrial activity began to recover, there were so many ex-soldiers of all ages who insisted on the right to earn a living where they had a right to live, that the Guilds could no longer secure the monopoly of their trades for their own Apprentices. From this moment the commercial value of the system began to decline.

9. For a long time the Guilds put up a strong fight for the field that they had held so closely, and, but for the unfortunately inseparable connection between Apprenticeship and monopoly in the Guild policy, they might still have succeeded in conserving for their

EDUCATION AND MANAGEMENT

country's benefit some of the best features of the system they had done so much to foster. But public opinion towards monopoly was fast changing, and when, early in the eighteenth century, this new opposition began to manifest itself in the law courts by decisions adverse to the Guilds, the day of their supremacy was at an end, and Apprenticeship suffered in consequence from reflected animosity. Even its political value waned, for, so soon as the Guilds lost the backing of the Courts, the boroughs no longer reserved their freedom for members of the Guilds, but found it more profitable to sell their "honours" cash down to the now numerous applicants for the Parliamentary franchise.

10. Apprenticeship as a national institution was dead and buried long before the repeal of the Statute of Artificers in 1813, for that event was something of an accident, brought about by the well-intentioned but misdirected attempt of certain people who sought to get the Act amended in accord with the times. For the greater part of a century it had been inoperative, and indeed it would most likely have passed into oblivion unheeded but for the above-mentioned endeavours to infuse new blood into its corpse.

11. As to the custom of Apprenticeship itself, this suffered a change in character that somewhat disguised its virtual disappearance, for the masters now began to demand premiums in return for their tuition and maintenance of the youths. Several causes were at the root of this change of custom, but fundamentally the whole national outlook and individual ideals were different. Instead of a self-supporting community consciously regulating its existence and assuring the continuity of corporate life, we see the triumph of individualism in the sale and purchase of special privileges for private profit. The master, free to hire unskilled labour as he listed, no longer has the same need of Apprentice help as of yore, and is unconscious of any social obliga-

EDUCATION AND MANAGEMENT

tion to undertake the craft-training of a fellow-man. The old system approached very nearly to the ideals of the modern co-operative principle, but with the breakdown of Guild monopoly the new régime entered upon an era of sheer barter, which, in due course, changed to a state of indifferent neglect as the factory system and joint-stock control expanded to a condition in which the pupil's premium was a sum of no relative importance whatever. (It is not without interest to remark that premiums of £1000 were not unknown in the middle of the eighteenth century, when the personal relations between the master and his pupil were still of a domestic kind.)

12. In its day, the English Apprenticeship system was undoubtedly a great force, and it remained an influence on the national life for nearly three centuries. It is, perhaps, easy to overdraw its virtues to the neglect of its vices, but there is at least the excuse that, whereas its merits were real and peculiar to the system, its defects were those of human nature and of the age. Apprentices worked throughout the day, and were only prevented by the Guilds from working into the night by reason of the inadequacy of artificial light as an aid to good workmanship. In their concern for the quality of the workmanship, the Guilds, in the heyday of their power, displayed a consistent conscientiousness that does them much credit, but it was a conscience that for long remained untouched by the softer humanities.

13. On the other hand, its harsh efficiency was, in many ways, preferable to the equally harsh negligence that succeeded it under the *laissez-faire* period of industrial history. In that time child labour descended to the depths of degradation from which a few like Robert Owen lifted it many fathoms, when in 1819 they secured a minimum age of nine years and a maximum day of twelve hours by an Act for Juvenile Employment. It

EDUCATION AND MANAGEMENT

was not until 1876 that the Elementary Education Act raised the age to ten years, and the fourteen-year age-limit of the present day dates only from 1899.

14. What would seem to-day to be one of the principal objections to Apprenticeship as practised in the Elizabethan period is the rigorous exclusiveness of the compartments into which it was divided, and there is no doubt that in any attempt to revive Apprenticeship as a national institution attention must be given to this important point. It is very difficult to assess the degree to which this condition was a difficulty in those days. It was certainly, in the main, more a consequence of the environment than due to any arbitrary rules. Trades were carried on, as has been explained, by Master Craftsmen, and not, as is now the case, in factories. Apprenticeship, therefore, was essentially as much a personal as a professional relationship, and it probably never entered any one's head in those days to consider the possible advantage of enlarging the Apprentice's educational career. So soon as the Apprentice had served his time, he became a member of the Guild controlling the monopoly of the trade that he had learned to practise, and it was by strengthening the monopoly itself that the craftsmen sought to enlarge their benefits. History has recorded how this idea ultimately failed to march in step with advancing civilisation, and it is a matter of importance to bear this in mind when considering the application of Apprenticeship to modern conditions of factory life.

15. The revival of Apprenticeship as a national institution under modern conditions is, however, a sound and desirable educational policy, provided it is recognised that a modern Apprenticeship is not a mere matter of documents, but is in its essence a tri-party agreement: firstly, by the boy to stay the course; secondly, on the part of the master to give education; and, thirdly, on the part of the parent to give moral and financial support.

EDUCATION AND MANAGEMENT

If in the master's conception of education the principle is accepted of giving enlarged facilities for training in selected departments as a reward for special merit, then the ordinary trade Apprenticeship becomes endowed with a breadth of outlook that might well render it one of the corner-stones of Reconstruction.

16. In the first part of this lecture the chief points emphasised were that an Apprentice Master and Apprenticeship constitute essential features in any good system of Industrial Education. In this, the second part of the paper, the salient factors of a good Apprenticeship are represented as :

- (a) The keeping of proper records.
- (b) The Special Apprenticeship as a reward for merit.

17. The Record is a vital item in the scheme, because it is the one material symbol of the principles involved in this tri-party moral agreement. It is the means by which the Apprentice Masters follow in detail the Apprentices' education, and it provides a valuable and sometimes much-needed check to those Apprentices who feel tempted to cut short an Apprenticeship about the age of eighteen in order to take up better-paid work. On no account should a certified copy of the record be given to any Apprentice who leaves under such conditions, for it is imperative to the principles of Apprenticeship that the record should be a certificate of the honourable fulfilment of a moral obligation. On the other hand, the frequency with which Apprentices do in some districts leave to better themselves about the age of eighteen is because the most able of them have already become skilled at their trades. It is precisely at this point that the principle of giving the best Trade Apprentices Special Apprenticeships becomes so valuable. The boy is placed in other departments, and is instructed in new work that not only widens his field of interest, but increases his com-

EDUCATION AND MANAGEMENT

prehension of the trade to which he is apprenticed, so that when he returns to his own job he is in a fair way to become qualified at an early age for some executive post as junior foreman, always assuming, of course, that he has the personality and other necessary qualities to make a success in such a position.

PART III

APPRENTICES AND PUPILS

1. The main question that arises in the minds of the majority of parents is how soon their sons can obtain wage- or salary-earning employment. The significance of this question naturally depends very much on whether any appreciable contribution to the cost of living is made by the employer during the training period, but in general it may safely be asserted that any form of real training involves financial sacrifice. The accompanying diagram (see Fig. I. page 23) is an attempt to show graphically the age at which wage-earning employment ordinarily begins under a variety of training systems.

2. The diagram in question relates more particularly to engineering, but is probably applicable to other industries. It is convenient to distinguish between the following categories of industrial youth :

Class A. Boys who leave school at 14.

Class B. Boys who leave school at 15.

Class C. Boys who leave school at about 16.

Class D. Boys who leave school at about 18.

Class E. Boys who leave the University at about 21.

3. Many boys of Class A begin their employment at the age of fourteen, and make no arrangement whatever for a proper training. Others, however, become Apprentices to specific trades, and the term of such an

EDUCATION AND MANAGEMENT

Apprenticeship is usually for seven years, although in many districts it terminates automatically at the age of twenty-one.

4. The significance of Class B is mainly of importance in those districts, where Junior Day Technical Schools are in operation, and employers are inclined to give preference to the boys who have received this preliminary form of education.

5. It has been customary for some firms, and it will shortly be compulsory under the new Education Act for all employers, to facilitate part-time education for boy labour and Trade Apprentices. It is also possible in certain firms for Trade Apprentices of particular merit to secure special facilities for obtaining a broader training during the latter part of their Apprenticeships. In the diagram, this is defined as a Special Apprenticeship. The well-known and very successful system that has been in vogue for so long at the Admiralty dock-yards incorporates this principle.

6. A few of those who obtain Special Apprenticeships may, by doing exceptionally well in their upper part-time school work, secure scholarships admitting them to a full College course, but the extent to which this is likely to take place necessarily depends, in the first instance, on the extent to which the higher local educational facilities have been developed. If such facilities are not available locally, it is highly improbable that this standard of educational ability will either manifest itself or be recognised.

7. Boys who have the advantage of staying at school until sixteen, which is the natural leaving age for the lower Secondary schools, ought, in the majority of cases, to be eligible for a more technical kind of training than the Trade Apprenticeship, and in the diagram they are defined as Engineer Apprentices. Their training is different from that of the Trade Apprentice, inasmuch as it is planned from the first to include experience in a

EDUCATION AND MANAGEMENT

variety of trades, whereas the Trade Apprentice seeks, in the first instance, to learn one trade thoroughly.

8. There is no uniform duration for these Engineer Apprenticeships, but, in those places where they are available, they terminate for the most part at the age of twenty-one. It is desirable that such Apprenticeships, although broad in their conception, should, nevertheless, be focussed upon the needs of the particular vocation for which the Apprentice is in training. It is also, of course, important to the success of such a scheme that the local educational facilities should be sufficiently developed to enable effective part-time school work to form an essential feature of the training. If this is thoroughly effective, a few of those who take this form of training will qualify for scholarships, if any are available, to the Universities and Technical Colleges.

9. In some districts where the local schools are not conveniently situated, it has been necessary for firms to organise educational classes on their own premises, and, where this is necessary, it is of course essentially within the province of the Apprentice Master. Under any circumstances, it is probable that more effective tuition in certain vocational subjects can be made on the premises rather than at school, and it is very desirable that employers should co-operate with the education authorities in such matters in order that the time devoted to part-time schooling may be made as effective as possible.

10. Although many boys who remain at Public and higher Secondary schools until the age of eighteen are unable or unwilling to go to the University afterwards, it should be clearly appreciated that one of the main objects of higher Secondary education is to prepare boys for University tuition, which forms the natural completion of a definite educational scheme.

11. Opinions differ as to the value of a University career in connection with an Industrial training, but the

EDUCATION AND MANAGEMENT

practical advantage of possessing the breadth of mind and the higher standard of knowledge that it is the purpose of the University to impart is not in question. Many men have attained eminence without University tuition, and the standard required for success in a number of Industrial occupations does not involve a full-time College course as an economic necessity. On the other hand, for those who aim at becoming engineers, for example, in the broader professional sense of the term, the higher standard of general and scientific knowledge that alone enables their services to be employed as required in any direction, is very necessary, and it is for those that the Universities and higher Technical Colleges offer direct educational facilities that it were foolish to ignore.

12. Assuming that a full-time College course is to be included in a particular scheme of training, opinions again differ as to whether it should follow immediately upon the completion of the school period or whether it should be taken after either the whole or a portion of the practical training. Those who favour beginning the practical training as soon as possible, do so mainly because it establishes an early association with labour and industrial conditions before the mind is subject to the somewhat specialised influence of University life. Those who disapprove this scheme do so mainly because of the possibility that organised academic work may be entirely interrupted in those places where suitable educational facilities do not exist, or the student himself is neglectful of this side of his training. A compromise that is in favour in some quarters is to take a year of the practical training immediately after leaving school, and to begin the College course with the subsequent October term.

13. In the English Universities the sessions comprise three terms each and occupy approximately nine months out of the year. In some cases students spend

EDUCATION AND MANAGEMENT

either the whole or the major portion of their long vacations in practical training, but it is not always possible to obtain facilities for doing this, and in any case they are more likely to be accorded to those already known to the firm through having taken a preliminary year's training.

14. *This principle of alternating the practical and theoretical work on what is known as the " Sandwich " system, has been developed to a greater extent in Scotland, where the two winter terms constitute a full session. This enables the student to spend alternate half-years at College and in practical training.*

15. Assuming that the total duration of the practical training is three years and the total duration of the full-time College course three sessions, the age at which the training is completed will vary from twenty-two, in the case of the six-months Sandwich system, to twenty-four in the case of the student who devotes a full three years to his University career. This latter alternative may well be an excellent scheme for those who can afford to travel in the long vacation.

16. It is convenient to distinguish between those who take a full-time College course and those who do not, and in the diagram the practical training for those who go to College is defined as a Pupilage. It is highly important that the practical and theoretical training should be suitably co-ordinated, and in order to achieve this it is necessary that the character of the Pupilage, like that of the Engineer Apprenticeship, should differ in many respects from that of the Trade Apprenticeship. The practical side of a pupil's training may reasonably aim at providing an even greater breadth of experience than is involved in the Engineer Apprenticeship, but it is inadvisable for a pupil to follow this course unless he is confident of his ability to attain the necessary standard, for there are obviously fewer vacancies in the field to which it leads, and the

EDUCATION AND MANAGEMENT

consequences of failure are likely to be more drastic. There is, on the other hand, nothing inconsistent in putting the same vocational focus on the Pupilage as on the Engineer Apprenticeship if it is in the pupil's interest to do so.

17. Whether the training is in the form of an Apprenticeship or a Pupilage, however, it is desirable that a more complete record of the detail of the training itself should be kept than has hitherto been customary, *and it is suggested that Apprentice Masters should adopt the practice of entering up, say once a month, some specific indication of the kind of work on which the Pupil or Apprentice has been engaged.*

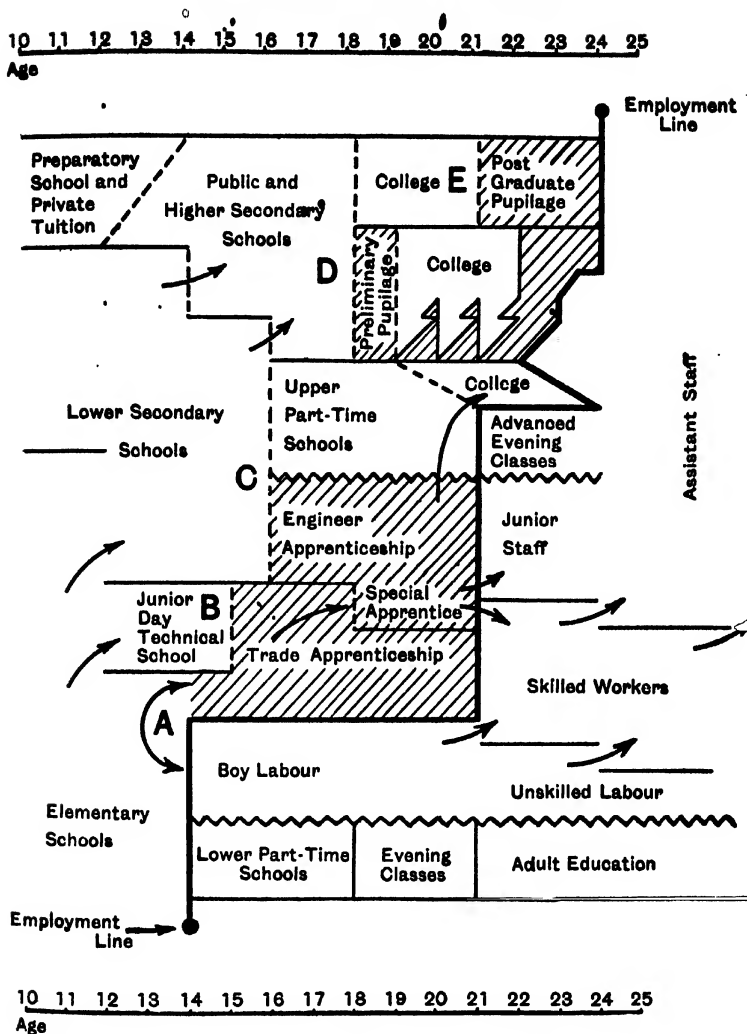
18. Attached hereto are samples of forms that can be used for this purpose. That relating to the works training (Fig. II. page 74) provides for an entry once a month, and each page, therefore, gives a concise record of the year's experience. The form (Fig. III. page 75) devoted to the school education is more particularly intended to facilitate the work of the Apprentice Master in encouraging the development of the younger apprentices. A similar form (Fig. IV. page 76) may be used in recording progress in college subjects. It will be observed that the special system of marking is so arranged as to draw attention only to those abilities that are distinctly above or below the average. It is, in general, hopeless to attempt any system of numerical valuation, but by merely putting a 1 against any abilities that are distinctly above the average strength, and a \times against any that are distinctly weak, a very concise and reasonably accurate record is obtained, and on this evidence the Apprentice Master can take proper action. As qualities of character are of even greater importance than academic ability, it is worth while taking considerable pains to acquire and to record information under this head respecting prospective trainees. The method

EDUCATION AND MANAGEMENT

above described is applicable in principle, and an example of how it may be applied is shown on Fig: V. page 77. It is not to be supposed that forms of this description are likely to be popular among schoolmasters, who traditionally write letters of recommendation recording commonplace qualities of normal magnitude. To those engaged in training, the essence of which is to bring education to a focus upon practical issues in the shortest possible time, the important thing is to know in what respects the boy is either above or below the average, because only by knowing this can intelligent assistance be given to those who need it. Boys leaving school are far from being fully formed, and the training period is in many ways a critical one in their lives. From this point of view, the Apprentice Master's position is one of considerable responsibility, and it is obvious that he cannot possibly do justice to it without the fullest possible co-operation from the schoolmasters who have had the boys in their prior charge.

19. With regard to the financial side of the question, conditions differ widely in different places, but there is an increasing tendency on the part of firms to pay salaries representing an appreciable contribution towards the cost of living during the training period. This applies in some cases to the Pupilage, although pupils still have to pay premiums for training in certain branches of Industry, more particularly where the Pupilage involves an intimate personal training. The term "Pupil" essentially implies some degree of personal influence, and the term has been chosen to define this type of practical training for this very reason, and in order to emphasise the obligation that is involved, even in places where it has not been customary to recognise it.

ENGINEERING TRAINING CHART



The above chart illustrates alternative schemes of engineering training appropriate to boys leaving school at different ages and having different objects in view. The employment line shown on the diagram indicates the approximate age at which the different schemes of training normally come to an end.

Industry has to absorb the five broad classes indicated in the chart by the symbols A, B, C, D, and E. Group A divides itself into those who take proper apprenticeships and those who become immediately labour. Group E represents the special cases in class D of those who complete a college course before taking any practical training. The arrows indicate the directions in which individual advancement tends to occur in favour of those showing special merit.

FIG. 111.

SCHOOL.

Name _____

This record is not to establish a numerical figure of merit but to be a helpful guide to those interested

[illegible]

COLLEGE.

Name _____

This record is not to establish a numerical figure of merit but to be a helpful guide to those interested.⁶

	YEAR						REMARKS & SIGNATURE.
	19						
	AGE						
ENGLISH :							
Industrial History							
Economics							
LANGUAGES :							
... ..							
MATHEMATICS :							
Graphics and Geometry							
SCIENCE : Physics... ..							
" (Lab.)							
Chemistry... ..							
" (Lab.)							
Microscopy							
Mechanics							
" (Lab.)							
Electrical... ..							
" (Lab.)							
Geology							
" (Lab.)							
ENGINEERING : Drawing and Design... ..							
Lab.							
Surveying							
Materials (Strength of)							
Metallurgy							
Structures							
Machines							
Engines... ..							
Hydraulics							
Economics							
Organisation							
GENERAL : Civil Engineering							
Electrical Engineering							
Mechanical Engineering							
Aeronautical Engineering							
Mining Engineering							
Naval Architecture							

FIG. V.

Name _____

[illegible]

OCCUPATIONAL DISEASES

Occupational Diseases

BY T. M. LEGGE, C.B.E., M.D., D.P.H.

N.M. MEDICAL INSPECTOR OF FACTORIES

A LECTURE DELIVERED ON FEBRUARY 18, 1919

IN the controversies and the legislation which have centred on the modern factory system, the student would readily distinguish, I think, three periods in which a fresh distinct appeal was made to the mind of the thinking public on the score of health.

The first was much the longest, extending over about half a century, from before 1800 to 1850—it cannot be said, indeed, to have been quite settled yet—and was excited by disgust at the excessively long hours worked by young children. In the controversies over this period the names of Percival, Owen, Oastler, Sadler, and Shaftesbury are household words. As a result of this outside pressure before 1850 the hours of children under 11 were limited to 48 a week, and of women and young persons under 18, to 69. That is, nine for the former, and twelve a day for the latter.

The second period extends from about 1850 to 1906, and during which, first, safety—that is, accident prevention by guarding of machinery—and subsequently, from about 1870 onwards, industrial disease prevention—became more and more prominent. The public feeling was stirred by the seriousness of some cases of lead-poisoning, with sequelæ of blindness and paralysis, in white lead and pottery manufacture, and the suffering from “phossy jaw” in the manufacture of lucifer matches. Notable features of the factory legislation between 1878 and 1895 were the provisions made to control dangerous trades by means

OCCUPATIONAL DISEASES

of special rules, and to obtain early knowledge of certain occupational diseases—such as poisoning by lead, phosphorus, arsenic and mercury, and anthrax—by placing the obligation to notify them on medical practitioners and occupiers. Finally, under the Workmen's Compensation Act, 1906, twenty-five occupational diseases were scheduled to which the Act, with differences depending on the essential distinction between accident and disease, applies.

The third period is that which we have just gone through during the war—return to excessively long hours and night work such as characterised the first period, with realisation of the strain, loss of efficiency and uneconomical character of the result so caused on the one hand to the individual, as shown by lost time, discontent, and dislocation of home life, and on the other to industry generally, in the many ways with which you are familiar. This has led to the application of the sciences of physiology and psychology to the study of the individual worker in all his relations to industry—mental, moral, and physical, known under the name of the study of industrial fatigue and welfare—in which your Director has played so distinguished a part.

I need not detain you as to the sharp distinction which exists between an accident, that is, something unforeseen, and disease, which is acquired gradually. The term "industrial disease" is a very broad one, and often loosely used. A little consideration will show there are three main divisions into which they can properly be classed : (1) industrial diseases due to poisons, inhalation of dust and infection, such as lead or anilin poisoning, grinder's rot, card stripper's and grinder's asthma, and anthrax ; (2) illness the result, on the one hand, of a weakening or breakdown in the mechanism of the central nervous system which co-ordinates muscular movements, and, on the other,

OCCUPATIONAL DISEASES

of repeated stress and strain on particular organs of sense or particular muscles. These are perhaps, in the truest sense of all, occupational diseases, and good examples of them are miner's nystagmus, boiler-maker's deafness, glassmaker's cataract, and twister's cramp. The third class—and I want to be very careful indeed in what I say about it—includes diseases common to the general public in which conditions of employment, by aggregation of workers, lack of ventilation, constant standing, lower vitality, and so predispose to them, such as consumption, pediculosis, anæmia, flat feet, etc. Of these it is most necessary to take account, because it was pointed out by Watson from the records of the Manchester Unity Independent Order of Oddfellows that occupation is a most important factor in considering sickness certification. And yet, in my opinion, this class cannot be regarded as occupational maladies in the strict sense of the term.

There is a fourth class which might be considered, namely, injuries which are not accidents, such as, for example, hernia, which is not scheduled under the Workmen's Compensation Act, and miner's beat knee and beat elbow, which are.

I return now to the first class—poisons, and the injurious effects produced by mechanical irritation set up by dust. The first question one has to put to oneself is—what is an industrial poison? I should define it as one that is employed, produced, or somehow occasioned in an industrial occupation, brought about and having its effect against the will of the worker, who may be unconscious of its presence, and, I would like to add, which occurs in the absence of sufficient precautions. Poisonings at one end merge imperceptibly into accidents, and the same substance can easily be the cause of accident when inhaled in considerable amount, and produce chronic disease when absorbed gradually. Thus when large

OCCUPATIONAL DISEASES

quantities of coal-tar benzene are inhaled, unconsciousness is speedily caused, and absorbed in small amounts from the air mixed with it, to the extent of, say, 20 parts per 10,000, will so act on the blood-producing tissues, such as the bone marrow, as to cause pronounced alteration in the constituents of the blood. This was the experience during the war, when, owing to the difficulty of obtaining naphtha, pure benzol was used instead as the solvent for rubber in the proofing of balloon fabric.

Of some of the principal industrial poisons, we have interesting statistical evidence extending now over twenty years. I am responsible for the whole of these figures and I do not want to deceive you as to the interpretation to be put upon them. Any industrial disease, however caused, which is reported must be regarded merely as a sample. Statistical evidence of industrial disease, therefore, always tends to give you *couleur de rose*; and this view I want you to apply to all industrial maladies which may be brought to your notice. They should merely excite in your minds the certainty that many of those exposed to the same conditions may have the malady in an undeveloped, latent, or neglected form by reason of varying susceptibility and temperament of one and another worker.

The reason is not far to seek. Notification of an industrial disease is a much more difficult thing than notification of infectious disease, because, in addition to distinguishing as specific symptoms which are common to other ordinary diseases—that is, differential diagnosis,—owing to the slow onset the patient passes through a stage of absorption which does not amount to poisoning in which the stigmata of the particular compound, as, for example, the blue line on the gums from lead absorption, and cyanosis of the lips from trinitrotoluene, are apparent. When it

OCCUPATIONAL DISEASES

became necessary to obtain statutory notification of the serious jaundice and atrophy of the liver due to tetrachlorethane and T.N.T., we did not ask the medical practitioner and occupier to notify T.N.T. poisoning, because, had that course been adopted, practically every worker in a dope room or T.N.T. who was away ill, from no matter what cause, would have been reported. We asked therefore, instead, for knowledge of a notable and serious symptom—jaundice—occurrence of which would show the necessity for investigation as to factory conditions. So I say samples are sufficient for statistics of industrial diseases, but for the factory you want more knowledge, not only of every case, but of all who show the premonitory signs.

Now look at these figures of lead-poisoning. Why is there the contrast between the figures for white lead works, china and earthenware manufacture, paints and colours, showing such a remarkable drop, and those for smelting, coach and ship painting, which have shown little or no improvement over a number of years. Like the honest surgeon I wish to publish the failures as well as the successes, as from the failures perhaps most is learnt.

LEAD-POISONING

	Year.		
	1913.	1904.	1900.
White lead	29	105	358
Pottery	62	96	200
Paints and colours	22	43	56
Coach-painting	71	60	70
Ship-painting	31	48	32
Lead-smelting	49	41	50

OCCUPATIONAL DISEASES

The chief cause, in my opinion, is a simple one, namely, that in the former, locally applied exhaust ventilation to remove dust and fumes at the point of origin can be effectively carried out, and in the others it cannot. On the practical side, there is little more to be learnt about lead-poisoning, and you can take it as axiomatic that all lead-poisoning arises from inhalation of dust and fume. This removed or prevented, there will be no lead-poisoning. You might demur to this statement in regard to coach and house painting, but believe me it is the sand-papering of painted surfaces which is responsible for most of the absorption. I do not wish to be misunderstood, and when, in enunciating a principle, I speak thus dogmatically, I do not wish at all to underrate subsidiary causes for minimising poisoning and so maintaining efficiency, such as cleanliness, periodic medical examination to detect the earliest signs and so direct attention to unguarded points in the process from which dust or fume *must* be coming off if signs of lead absorption are present. Labour-saving devices, especially in the white lead industry, have helped materially; and in the china and earthenware industry the most recent drop is due to successful research in using a lead glaze with as much lead content as before, but in a form insoluble in the gastric juice. The employer must make his process fool-proof, as he can do, and not place reliance on the workman. And this I say in no disparagement of him, because his attention is sufficiently engaged in looking after the process, let alone thinking of himself. The Works Manager and the Foreman must render the process safe, and not the workman.

Consider for a moment what an amount of invalidity is represented by these figures for lead-poisoning alone. Plumbism is a chronic malady involving absence in the mild acute cases for less than four weeks, and in the severe chronic cases of wrist drop,

OCCUPATIONAL DISEASES

incapacity, often total, lasting for months and months. Taking an average of absence from work of two months per case, for 1903 alone this represents 80 years of lost time.

The total amount paid for compensation in 1913 under the Workmen's Compensation Act was nearly $3\frac{1}{2}$ millions, of which over £130,000 was for occupational disease. Over 90 per cent of the claims for industrial disease (nystagmus, bent knee, etc.) occurred in the mining industry. The annual charge for compensation per person employed was lowest in factories, being only 5s. per person; in the case of railways it was 8s. 5d., in quarries 10s. 3d., 13s. 3d. in constructional work, and in mines 24s. 3d. The total charge, including cost of management, commission, legal and medical expenses, cannot have been less than 5 millions.

Turning now to poisons which act directly by absorption through the skin, the best examples are to be found in the intermediate substances obtained from coal tar and used in the manufacture of explosives and dyes. I can best illustrate what I mean by two examples—anilin oil and trinitrotoluene. I remember very clearly an inquiry in Lancashire into the death of a workman in a dyeworks. It was a very hot day and he was taking the cork out of a cask of anilin oil when, probably because the heat of the sun had caused pressure inside the cask—work was being done in the open air,—some of it splashed on to his face and clothes. He washed his face but did not change his clothes, and after working for an hour went home. He became unconscious and never recovered. It was noticed when he returned home that his lips were quite blue and that he staggered and appeared like a drunken man. In that instance the fact that the man did not change the clothes on to which the anilin had been spilt, and did not rid his skin of it by a bath, cost him his life from absorption through the skin, and it is in

OCCUPATIONAL DISEASES

the same way in large measure that all illness from nitro derivatives of benzene and toluene is caused. In pre-war time we knew very little of the effects of trinitrotoluene—so little was it used. The chief impression, however, was that it was much less poisonous than dinitrobenzene, of the injurious effects in the manufacture of which we had considerable experience in Huddersfield. As long ago as 1901, Dr. Prosser White, the Medical Officer at the Roburite Explosives Works near Wigan, and Dr. J. Hay of Liverpool, by experiments on themselves—rubbing small quantities of an ointment containing dinitrobenzene on to their skins—showed unmistakably that it was quickly absorbed through the skin. And about the same time similar effects were described here in Manchester by Dr. F. W. Dearden and Professor Knecht in a paper on "The Injurious Effect of Fast Anilin Dyeing Processes." The great effect of the compound was noticed in the change it brought about in the blood. The red blood cells varied very much in size and were altered greatly in shape ; instead of being round they became pear-shaped and irregular in outline, and the number of the red cells was diminished. Further, when the ear, for example, was pricked, the blood was not red but chocolate-brown. The change was due to an alteration in the blood-colouring matter, which prevented it carrying oxygen from the lungs to feed the tissues of the body as efficiently as pure blood would. In this way the symptoms of headache, drowsiness, shortness of breath, and blueness of lips were brought about. Very occasionally jaundice would appear, and in one fatal case which I remember at Huddersfield the liver was found after death to be much wasted and diminished in size.

With regard to T.N.T., experience in pre-war time, as I said before, seemed to show that it was much less poisonous than D.N.B. Dr. Prosser White indeed

OCCUPATIONAL DISEASES

had said it was not poisonous in ordinary use, a statement which was quite true at the time he made it, when no one could anticipate the extraordinary use of the material. It came as a surprise, therefore, when the workers in the National Filling Factories began to suffer from frequent illness, which in nearly all serious cases assumed the form of jaundice. Ordinary jaundice is never fatal, and this showed it to be quite different from that, as the mortality rate among those suffering from it was very high—about 30 per cent.

The arrangements for the comfort and well-being of the workers in regard to change-rooms, over-alls, washing accommodation, and meal-room accommodation had been well considered and thought out ; and the general plan of the factories as regards lighting, heating and cubic space was ample ; yet, as the poisonous nature of T.N.T. had not been anticipated, the conditions were for a short time baffling, both as to the essential cause and the best means of prevention. In the process of filling with the molten amatol mixture containing T.N.T., or with the pure T.N.T. in powder or ammonal mixture in powder, the quantity of fume and dust given off made one naturally forget White and Hay's experiments on skin absorption and attribute too much of the poison to inhalation of the dust and fume. Efforts, it is true, were made to prevent absorption through the skin by the provision of gloves, and of the dust by wearing respirators. It is easy to suggest the wearing of gloves, and gloves were provided and worn by the million, but they never adequately protected the skin, as the powder or moist T.N.T. penetrated and percolated through, converting the gloves inside more into a poultice of T.N.T. than anything else. It was found that the wearing of respirators for any length of time was impracticable. In the summer of 1916, Dr. Benjamin Moore, F.R.S., working with his assistants in a T.N.T. factory for

OCCUPATIONAL DISEASES

the purpose of discovering the cause, repeated with T.N.T. very much the same experiments which Prosser White had made with D.N.B. He rubbed into the palms of his hands an amatol pellet containing 20 per cent of T.N.T. In two hours traces of T.N.T. were noticed. He kept up the rubbing into his hands intermittently for about six hours, and for a period of ten days after the presence of T.N.T. was detected, and not only could the T.N.T. be detected chemically, but he also suffered from illness. Here then was proof that contact with T.N.T. ought to be avoided as much as possible. Thus the right measures of prevention were proved to be cleanliness of work, cleanliness in every meaning of the word, prevention of dust and of contamination of any part of the skin by the substance.

On the 1st January 1916 it became the duty of every medical man treating a case of toxic jaundice contracted in a factory or workshop to notify it to the Chief Inspector, and in this way we have since then been able to watch from month to month the progress of the measures taken to reduce the poisoning. The following are the figures arranged in quarterly periods for 1916, 1917, and 1918 :

<i>Year</i>			
1916	.	.	6 ⁴ , 16 ⁵ , 73 ²¹ , 86 ²² .
1917	.	.	83 ¹² , 56 ²⁰ , 21 ⁸ , 29 ⁴ .
1918	.	.	13 ⁴ , 6 ² , 5 ² , 10 ² .

(The raised figures indicate fatal cases, and are included in the lower figures.)

These show how great was the increase at the end of 1916 and the beginning of 1917, and how then, when we knew the cause and were able to take effective measures, the improvements carried out in the factories practically caused the disappearance of illness from T.N.T.

No better example of poisoning by absorption of

OCCUPATIONAL DISEASES

a vapour through the lungs, and of how it can be prevented, could be given than that of the doping of aeroplane wings. The basis of the dope consists of acetate of cellulose, but in order to apply this it must first be dissolved, and then it is applied with a brush. Shortly before the outbreak of war, certain organic compounds, chlorine compounds of ethane and ethylene, had been manufactured by an inexpensive process, and as they were non-inflammable they appeared to have a useful function as solvents of fat, resin, and rubber. One of these, tetrachlorethane ($C_2H_2Cl_4$), which chemically is closely related to chloroform, was the compound which at the commencement of the war was employed as an ingredient of the dope, being present usually to the extent of about 12 per cent, the rest consisting of acetone benzol and methylated spirits. As you see, the method of applying the dope is very much the same as in painting. Each doper carries the mixture in a can in his left hand, and with his right brushes it on the wing, which is supported on trestles. Three or four coats of dope are put on, each coat having to dry before the next is applied. As the wing of an aeroplane is too wide for one person to stretch across it, two work simultaneously opposite each other. Each worker has to lean over the wing, and hence it is impossible to escape inhaling the fumes with which the atmosphere is charged. The dope, however, is considerably heavier than the air—tetrachlorethane vapour itself being six times heavier—so that its fumes tend to fall to the ground. This is a very important point to remember in explaining the manner in which the poisoning occurred. Two months after the war began, a man died in an aeroplane factory with symptoms of jaundice, and on going to the factory I found that 19 men from all parts of the big shed were away suffering from jaundice. The shed was a very large one and had originally been a

OCCUPATIONAL DISEASES

tramway depot. It was supposed to be very well ventilated by a plenum system—that is, by a fan which forced the air into the room through a system of air trunks with branch ducts opening about two feet from the floor level ; but seeing that the vapour is heavy and collects on the floor, this system was the very worst that could have been adopted and served merely to stir up the vapour and distribute it to all parts of the shed.

Now, what was the remedy ? The first idea would be to give up the use of the poisonous substance, and the second, to introduce pure air and as constantly to remove it by fans, so as to reduce the amount of poisonous vapour present. Unfortunately, at that time it was impossible to give up the use of the material, as no other substitute was known, and consequently recourse was had to the second. The size of the wings unfortunately made it impracticable to remove the vapour as one would like to have done, by applying the exhaust ventilation locally at the point where the fumes arose. Hence reliance was placed by the Inspector of Dangerous Trades, Mr. W. Sydney Smith, now Superintendent of the Royal Aircraft Factory, Farnborough, on a low-velocity scavenge of the air contents of the dope room. Fresh air at low velocity is drawn into the room by the suction of exhaust propeller fans, placed at the floor level, because of the heavy nature of the fumes. Air inlets of ample size are placed in the other side of the room at a height of 8 to 10 feet—this air being heated by passage through radiators or piping heated by steam or hot water. The standard of ventilation for the room is thirty changes of air per hour ; thus the whole of the air is changed every two minutes. You might think such rooms would be draughty, but there should be no perceptible draught if properly arranged. The secret of preventing draughts is to have the area of

OCCUPATIONAL DISEASES

the fresh air inlets at least three times the area of the exhaust fans. At the beginning of the war, I said, there were about 30 dope rooms ; at the end there were considerably over 400, and every one of them was ventilated very much on this principle of thirty changes of air per hour.

This is not quite the whole story in regard to doping. If there are poisonous substances which can be dispensed with in a factory, then naturally it is to every one's benefit to get rid of them, and, seeing how impossible it was to remove the fumes at the point of origin, efforts were made to eliminate tetrachlorethane. Fortunately by September 1916 this was achieved. Before tetrachlorethane had been given up, at least 70 cases of jaundice with 12 deaths had occurred, but since that time there has been no death and jaundice has disappeared. The dopes now used, however, still contain benzene, usually in a proportion of about 19 per cent, acetone substitutes, methylated spirit, and other ingredients, and the temperature of the room must be kept at 70° F. at least, so that in order to make the conditions as healthy as possible—they cannot, I fear, be made exactly pleasant because of the alcoholic vapours constantly given off—this standard of ventilation is still insisted on and maintained.

The lantern slides I have just shown you have a much wider application than for the industry in question. They seem to me to indicate the right lines on which ventilation of work-rooms in which persons are aggregated together should be approached, but instead of thirty changes of the air of the room per hour it may not be necessary to ask for more than four or five. Experience shows more and more that it is, as Dr. Leonard Hill, F.R.S., has said, "the physical and not the chemical conditions of confined atmospheres which influence health and happiness. Over-heated and still air decrease the activity of the body furnace

OCCUPATIONAL DISEASES

and so lead to lessened resistance to disease." Movement of air, on the other hand, producing an adequate cooling of the skin is what should be sought for in ventilation. My contention, however, is that through ventilation by mechanical means causing a scavenge of the work-room can only be successful when the incoming air is admitted through sufficiently large inlets to prevent the sensation of draught and is at the same time warmed to a temperature of about 60° F. Introduction of moving air in this way will, I think, reduce the evils due to aggregation of persons in work-rooms, such as consumption, anæmia, and debility, as far as this can be done by means of ventilation.

No better example of the ill effects produced by inhalation of injurious dust need be cited than that in card-stripping. In the year 1908 only one or two cotton mills had made attempt to remove the dust in stripping coming off in the amount you see in the slides. In that year I asked my newly appointed colleague, Dr. Collis, to make examination of the strippers and grinders, and among the 126 men so employed he found 73.8 complaining of, or suffering from, an asthmatic condition due to inhalation of the dust. Manufacturers set themselves promptly to remove the dust, and it is interesting to have watched the development of the exhaust system applied first by ducts with fixed hoods at some distance from the card, then by movable hoods brought nearer to the card, and finally the application of the vacuum system of cleaning, in which first a pump created the vacuum, but later, as more economical, exhaust steam. Not only are men now able to return to the work which they formerly had to leave, but the industry itself has benefited by the removal of dust which damaged the machinery.

I would say a word now on those strictly occupational diseases due to stress and strain. I regard them

OCCUPATIONAL DISEASES

simply as cases in which physiological strain has passed the border line and become pathological. As Professor Kent has said, "The process of fatigue is not an injurious one to be prevented if possible, but a normal one essential to the well-being of the tissues. "Only when the breaking down is exaggerated and when the process of repair fails to keep pace with the process of destruction does fatigue of an injurious grade supervene." Thus, in persons of neurotic or anxious temperament the central nervous system fails to co-ordinate the muscular movements and you have writer's and telegraphist's cramp.

Man was not intended to spend his days in the bowels of the earth where practically all the light falling on the surface is absorbed and hardly any reflected, and he pays for the strain on the eyes thus incurred by nystagmus. In his case the essential thing is to make the unnatural conditions natural as far as possible by increasing the amount of light given off by the safety-lamp.

On the other hand, the glass-bottle finisher's eyes suffer from excessive light. His eyes were not made to stare into a furnace at a temperature of 2000° C. for hours daily, and he pays for it by a peculiar form of cataract, very slow in development, which, commencing just at the nodal point at the back of the lens where the pencils of rays cross and pass without refraction, is known as a posterior cortical cataract. The position, commencing right in the centre of the lens, distinguishes it from ordinary senile cataract, which develops from the periphery.

Some time ago I examined the eyes of 513 glass workers and found evidence of this cataract present in 45 right eyes and 64 left eyes, whereas in 278 controls it was present only in one man, who proved on inquiry to be an annealer and so had to stare into a furnace. In the glass-bottle-making industry the

OCCUPATIONAL DISEASES

introduction of that wonderful machine is to be welcomed which, requiring the attendance of two men only, sucks up the molten glass, blows the bottles, and delivers them at the rate of 40 a minute. And perhaps one is glad, too, as helping to tide over the time of transition and prevent unemployment of old workers, that the dexterity of the machine as yet is not such as to enable it to place the marble inside the ginger-beer bottle—a trick which must still be done by sleight of human hand.

Similarly, industrial deafness from loud noises is not due, as popularly supposed, to a bursting or weakening of the drum of the ear through which sound is conveyed to the brain. Indeed, the effect of noise, as it affects the boilermaker and others, is not so much to interfere with the sound-conducting part as to destroy the sensitive nerve-endings, the delicate nervous structures of the internal ear which constitute the sound-perceiving apparatus. That part of the sensitive membrane which acts as the receiving board of impressions of high-pitched notes has been found to have completely disappeared as the result of this continued stimulation. No boilermaker employed for any length of time escapes becoming deaf, and the disability is such that three-fourths of them cannot hear at all at a public meeting, or hear only with difficulty.

Application of the experimental methods chiefly carried out in this country by Professor Kent on industrial fatigue will throw a flood of light on this class of occupational disease, and, perhaps by suggesting alternation of employment, render the outlook in regard to them more hopeful than I see it now. What wonder is it that the twister in the cotton trade who by a dexterous twist of his fingers joins up 8000 threads per day at his prime finds his earning capacity reduced when, day after day and year after year in

OCCUPATIONAL DISEASES

repeating this movement, his fatigued fingers can join up only 600. And I believe that the problems which have already been gone into so elaborately in regard to the effects of artificial humidity and other causes upon health will have to be revised in the fresh light which can be brought to bear from the study of industrial fatigue.

An industrial disease always with us is anthrax, a splendid antagonist invariably making a frontal attack, and therefore in this respect very different from the slinking and slow methods of lead-poisoning and fibroid phthisis which take years to develop and incapacitate. With anthrax a fortnight is time enough for either cure or kill. I show you the figures of incidence of anthrax in the worsted and woollen industries.

Five-yearly Periods

	1901-5	1906-10	1911-15	1916-18 (3 years)
Wool . .	98 ²⁰	130 ²¹	164 ²²	198 ²³

What is the meaning of the increase in the figures? To few subjects has more attention been given than to the prevention of anthrax in industry. Special Rules and Regulations have governed the wool industry for a quarter of a century, requiring, among many other things, downward exhaust ventilation in opening and sorting. This has obviously been of little or no avail. Why? Because effort has been directed to minimise the effect and not to get at and destroy the cause. That has hitherto been considered too difficult—the anthrax spores being among the most resistant organisms, and saturated steam, effective certainly in destroying the spores, unfortunately destroys at the same time the material for manufacturing purposes.

Still, the situation could not be left as it was, and

OCCUPATIONAL DISEASES

during the war I am glad to say a good deal has been done. Prolonged experiments have been carried out by a Committee in Bradford, upon which served Dr. Eurich, Bacteriologist of the Anthrax Investigation Board, and Mr. G. Elmhirst Duckering, a colleague in the Factory Department and a skilled chemist. The experiments were controlled here in Manchester by Professor Delépine. The Committee elaborated a chemical method capable of disinfecting wool on a commercial scale and as a business proposition, by which the disinfection of dangerous wools, carried out in the country of export, under the direction of the British Government, will be made to pay for itself by a charge of not more than 1d. a lb. on the wool. Already this year the expenditure has been sanctioned for the erection of a trial disinfecting station, and I hope that before long the menace of anthrax which has hung for so many years like a nightmare over Bradford, Kidderminster, and the Rossendale Valley of Lancashire will disappear. This will be a signal triumph for scientific research applied to industry. No less is another point connected with anthrax a triumph of such research. You will notice that while the cases from anthrax have gone up by leaps and bounds it is not so with the deaths. That I attribute largely to the new treatment introduced systematically about 1908, of injection of anti-anthrax serum sometimes with, but now more often without, excision at the same time of the malignant pustule.

On the lines of scientific research applied to industry, with the stimulus for it coming from within the factory and not exerted from without, as has been too much the practice in the past, I foresee very great progress and increased efficiency in the course of the next few years.

AMOSPHERIC CONDITIONS AND
EFFICIENCY

Atmospheric Conditions and Efficiency

By LEONARD HILL, F.R.S.

A LECTURE DELIVERED ON APRIL 1, 1919

I PROPOSE to consider to-day the influence of the workshop environment on the efficiency, health, and duration of life of the workers, a subject which is of very great importance, and well worth the closest attention and consideration. The discomfort produced by close air of crowded places is appreciated by most of us, and that ill-effects arise from such is universally recognised by the hygienist, but the exact way in which these effects are produced is by no means understood by the public at large, and erroneous ideas are widely held.

We see consumptives treated in open-air sanatoria, feeble people in a state of consuming fever placed in rooms—the windows of which are never shut—with a through draught, or in open-air shelters in the coldest winter weather. We learn that the wounded do exceedingly well in hospital sheds built on the plan of the verandah, or in tents, and that they die from septic infections far more often in close, crowded buildings; that delicate children, those subject to colds, those with weak hearts, those over-nervous in temperament, those in risk of tuberculosis, when sent to open-air schools and treated therein according to plan, by good food, adequate rest, and open-air exercise, grow so fast in weight that their growth-curves escape from the official charts used for records. We have seen tens of thousands of weedy

ATMOSPHERIC CONDITIONS

citizens, conscripted, well-fed and exercised in the open air, broadening out and becoming handsome, virile-looking soldiers, so developed that their old-time 'civvy' clothes are useless to them when they become demobilised.

Trial has proved that cows with their natural coat of hair—they have no overcoat to put on—yield more milk and improve more in condition when wintered out in the open fields than when kept in stalls, and that stall-feeding is the cause of tuberculosis in them. All this is known to the observant, but yet the mass of people are imbued with the fear of cold, of exposure to weather; they shut up windows, confine their children within doors, over-clothe their bodies, over-heat their houses, and lead a caged life, wholly different from the life of a wild animal, from that of a wild man from whom we are descended, they who inherit a body tuned to fight the rough conditions of the world through hundreds of thousands of years of man's existence thereon.

The common belief is that a close atmosphere acts harmfully upon us through the chemical impurity of the air, that there is too little oxygen or too much exhaled carbonic acid in such, or subtle organic poisons supposed to be exhaled in the breath, or from the bodies of people. This chemical theory, which is entirely erroneous, has done the greatest harm to the development of our cities, for it has been accepted that, so long as the air came up to certain chemical tests of purity, no mischief was done; thus slum dwellings and cavernous places of business were permitted by the State to grow up in place of garden cities. The land exploiter and jerry-builder for a hundred years have had their way untrammelled, and brought us now to a condition of industrial unrest most difficult to meet, to vast areas covered with villainous tenements and mean houses, an evil almost irreparable in magnitude.

The truth is, that the concentration of oxygen is

ATMOSPHERIC CONDITIONS

never reduced in the most crowded, close atmospheres to anything like the extent it is in mountain health resorts, where the air is attenuated owing to altitude. Further, the concentration of carbonic acid, as was first shown by Dr. John Haldane, in the depths of the lungs is always kept at about 6 per cent of an atmosphere, and the breathing is so regulated as to keep it at this figure. A little more carbonic acid in the air only excites in us a little deeper breathing, just as exercise does, owing to the production of more carbonic acid in the body, and it is only when the carbonic acid rises to a concentration which is never approached in a close room that any loss of efficiency arises from the deepening of the breathing.

The crews of submarines find on submergence that the confined air can be endured for some twenty-four hours, until the carbonic acid reaches 3 per cent and the oxygen is correspondingly diminished. Fishermen greatly exposed to cold by day shut themselves up in cabins and sleep in an atmosphere where the oxygen sometimes becomes so reduced that the lamp goes out, and no harm comes to them from this. On the plateaux of the Andes there are great cities where the people are acclimatised to a concentration of oxygen equal to some 14 per cent, instead of the normal 21 per cent at sea-level.

As to the presence of organic poison in close air, the most careful and repeated experiments by the best physiologists in various countries have failed to reveal this. The assertion that there were such poisons was made on the evidence of untrustworthy experiments, which unfortunately gained the widest attention and credence, and now all the popular writers and lecturers on hygiene preach a false doctrine which it is considered almost irreligious to controvert.

Close air, in truth, produces its harmful effects in two ways :

- (i.) Through its physical qualities, its lack of

ATMOSPHERIC CONDITIONS

adequate cooling and evaporative powers acting upon the skin and the respiratory membrane.

(ii.) Through the spread of infection from carriers of the germs of disease.

The germs of respiratory infection—colds, sore throats, influenza, measles, etc.—are spread by the spray coughed, sneezed, or spoken out by carriers, and inhaled in massive doses by those who are in close proximity, or by kissing—a direct-contact infection. The germs of typhoid fever and similar complaints may be spread by dust from the soiled clothes of carriers, or by carriers handling food with soiled hands, for example a carrier recovered from typhoid fever in some cases continues to pass a virulent strain of germ in his urine, and if he be a cook or milkman, his hands, soiled with his urine, may transmit this disease to others. I cite a recent example published in a German medical paper : An unrecognised dysentery carrier peeled potatoes which had been boiled in their skins for the purpose of making a potato salad, which formed part of the very meagre meal arranged for the celebration of the Kaiser's birthday. The warm mashed potatoes were left for hours to incubate the germs of the disease, and scores of those who partook of this potato salad were infected. The evacuations of carriers may pollute water or milk supplies through drainage leaking into wells, streams, etc. ; or flies may carry infection from their evacuations to food ; the germs which infect wounds may be spread by dust from skin and soiled clothes or by flies ; the germs of other diseases are spread by the bites of insects, *e.g.* malaria by the mosquito, while trench fever and typhus are spread by body lice, which bite and cause scratching, and so transmit infection. The germs of venereal disease, most potent in their after effects and in reducing the efficiency of the nation, are spread by direct contact in sexual intercourse. The infective diseases not only produce illness and death at the time of

ATMOSPHERIC CONDITIONS

infection, but leave behind a host of degenerations of tissues which weaken efficiency and shorten life.

Now obviously all these methods of infection may be very greatly reduced by strict application to the laws of cleanliness. First of all, places where people crowd together require to be well ventilated and lighted ; the wind sweeps away spray infection and prevents massive doses being inhaled ; sunlight is the greatest germicide ; proper provision of wind and sun is almost totally neglected in the dwellings of the mass of the people ; the bathing of the body and washing of clothes require to be universally and frequently carried out, as set forth in the laws of Moses in the Book of Leviticus. And how lamentably the nation fails to obey these laws ! Cleanliness will get rid of insect-spread disease, preventing flies, mosquitoes, fleas, lice, which are all bred of filth, lessen dust-spread disease, and food contamination by carriers. Moses and Mahomet both knew the value of cleanliness and the need of teaching it to the plague-ridden, dirty people in the East. Bathing after sexual intercourse—a law of Moses—the cleansing being carried out with a suitable germ-destroying material, will prevent infection from venereal disease ; the provision of facilities for such, proved to be of the utmost value in warship and camp, require to be made available to all, for example, in every large public lavatory, public bath, and wash-house.

Factory surgeons are required who will move among the workers, not sit in a consulting-room waiting for patients ; who will teach the workers to prevent disease, pick out incipient cases of illness, ward off trouble arising from over-fatigue by ordering rest, investigate and prevent industrial causes of over-fatigue, and the injurious influence arising from dust or fume produced in trade processes. Such surgeons are also required to grade workers according to their physical strength and temperament to the work suitable for them, *e.g.* to turn

ATMOSPHERIC CONDITIONS

the man with a weak heart from dock-labouring or coal portorage to basket-making or loom-minding; to arrange short shifts for those returning from convalescence, and induct them gradually once again into full working hours; to regulate intervals of rest and inculcate the need of open-air exercise for sedentary workers; to see that the food supplied in canteens provides the energy required for the work done, and satisfies the needs for growth and health in accordance with the discoveries of science; in particular, to secure in the diet an adequate supply of vitamins, which are present in fresh natural food and are destroyed by the artifices of the miller and canner, and of the essential building-stones of the body which are not equally present in all proteins. Much ill-nutrition and disease arising therefrom may thus be saved.

Ill-nutrition may arise because food is deficient in energy value or in quality, or because the environment depresses the metabolism and reduces the vigour and appetite, *e.g.* the environment of a tropical, humid climate, or because the body is over-fatigued, and the expenditure, particularly of nerve energy, overpasses the digestive and absorptive powers. Over-fatigue is, no doubt, one of the great causes of consumption, and those who carry out in factories skilled hand operations, doing piece-work or keeping up with the pace set by a machine, seem specially liable to it. Heavy workers suffer far less, *e.g.* coal-miners, smiths and foundry men, and agriculturists. Boot and shoe makers, printers, and cabinetmakers have a relatively high mortality from consumption. Merchant seamen who are confined in very close quarters on board ship have a rate thrice that of coal-miners. Heavy workers make relatively few movements (moving legs and body as well as arms), they breathe deeply, have a high rate of metabolism, and require, and generally secure, good ventilation, many by working out of doors. The light hand-workers lead a far more caged and less well-ventilated life, using their

° ATMOSPHERIC CONDITIONS

hand muscles to make many small, fine movements, not using their big body and leg muscles, not breathing deeply, not having a high rate of metabolism. The chest is fixed to make skilled hand movements, and this modifies their breathing. The number of fine skilled movements they have to make brings about nervous fatigue, while their metabolism being relatively low, and breathing shallow, the onset of fatigue is not resisted as it should be by a high rate of nutrition. The relatively warm environment brings too much blood into the skin of the factory-workers, and does not tone up the body as the open-air life does. Infection with catarrhal complaints is far more spread among them, and their respiratory membrane is not kept in a healthy state as it is in those who deep breathe cool, dry air.

The expectation of life at birth is sixteen years less in the big city than in the healthiest districts. Of those who survive over fifteen, the average duration of life among pure agriculturists is sixty-seven years, among pure industrial workers fifty years. Of the recruits examined for the army, over a million were found defective. In some occupations almost all over forty years of age were incapable of becoming soldiers. Insurance returns show that in some occupations 40 per cent of the workers may be away from work each year for some period owing to sickness, while the number of cases seeking medical relief may number 100 per cent of the workers or even more each year. The economic loss is gigantic. The conditions which produce this loss depend on (1) bad housing, (2) poor food, (3) ill-arranged hours of work and rest, (4) atmospheric environment of workshops.

Eight millions of the people are estimated to live in one- to three-room tenements; millions more live in dwellings in mean streets. The workers have no opportunity of relaxation and refreshment in gardening, in open-air games and walks in pleasant country surround-

ATMOSPHERIC CONDITIONS

ings. Natural beauty has been ruthlessly destroyed, and the cinema and a sensational press take the place of fun and frolic in the open air. The caged, crowded life of the tenement lowers the vitality and exhausts the nervous system. Ill-feeding comes on top of this ; the workers having no garden—containing vegetable foods—lack the fresh vitamines. An enormous economic loss results from their having no chance of spending their leisure hours in gardening and in improving their homes.

The sophisticator of fresh foods, the miller and canner, imposes his wares upon them. Tea, sugar, white bread, nut-margarine, and low-quality jam, wholly deficient in vitamins, are the staple foods of the poor children. It is estimated that 80-90 per cent of the London County Council school children suffer from rickets in so far as shown by decay of teeth ; they have a lessened vitality and health and resistance to disease. This is attributed to deficiency of fat soluble vitamins (E. Mellanby), and the deficiency is brought about firstly by want of butter and milk from grass-fed cows, the milk of which is rich in vitamins, and of milk of mothers fed on vitamine rich food. The mothers are wrongly fed and their milk is poor in vitamins ; the cows are shut up in the winter in stalls and fed artificially, and their milk is also poor in this essential property. Secondly, the deficiency arises from caged life in tenements ; over-clothed, over-sheltered from open air, they have a low rate of metabolism, a poor appetite, defective digestion and absorption. Millions live in tenements in which no breeder would think of raising his animal stock ; in such places are bred and made degenerate the children of this great British Empire.

Of the excellent results that follow the institution of canteens in munition-works and supply of well-chosen and well-cooked food I need not speak.

It is recognised by educational authorities that children require a change, and run round in the open

ATMOSPHERIC CONDITIONS

air every hour to keep them fresh for lessons. Factories should be built narrow, so that they can empty quickly, with playing courts around, where workers, whose needs are no less, can secure a few minutes' relaxation. The building of acre-big workshops is against the reasonable control of the workers' health.¹

Children require change in their lessons, and a change of occupation is as good as a holiday. No attempt is made to bring this about in factories. A worker should do one thing in the morning and another in the afternoon, or even change, not only after dinner, but at eleven and again at four, with a ten-minutes' interval at eleven and four, spent whenever possible in the open air. By changing shops and changing work, hateful, depressing monotony would be avoided and freshness obtained. There are workers who follow all day exhausting operations, which bring them to an early breakdown. A change to a light, easy occupation for half the day could easily be arranged by wise co-ordination of work in factories. The war has shown how quickly a man, a boy, or a girl learns a process which was considered skilled. It is nothing to human endeavour to learn half-a-dozen processes, and escape from monotony by changing from one skilled occupation to another. Let the workers see to this ; it is up to them to bring about such a change.

I now come to the subject to which I particularly want to draw your attention to-day, viz. the relation of efficiency to atmospheric environment. I have introduced into use an instrument, the kata-thermometer, which measures, firstly, the rate of cooling of a surface at body temperature—cooling by convection and radiation,—secondly, the rate of evaporation from a moist surface at body temperature. (In the Appendix I give the directions for using this instrument.) The ordinary thermometer is a static instrument, indicating its tem-

¹ A greenhouse atmosphere is obtained in big factories lit by skylights.

ATMOSPHERIC CONDITIONS

perature in relation to the environment, but the body is a dynamic instrument, a machine keeping itself at body temperature, doing work and producing heat by the combustion of food, and requiring to be so cooled that the body temperature remains approximately at blood-heat. The body, in cool surroundings with moving air, is adequately cooled by the loss of heat by convection and radiation taking place from the skin, by evaporation from the respiratory membrane brought about by breathing and by the heat spent in warming up the air breathed. In such cool surroundings the skin is then comfortably dry and evaporates but little moisture. In over-warm surroundings the skin sweats, the emergency method of cooling coming into play. Every gram of sweat carries away in its evaporation 580 calories of heat, so the emergency method is very effectual, but to put it in play, glandular secretion and a greatly increased flow of blood to the skin are required, with a correspondingly increased expenditure of nervous energy, and extra work on the part of the heart. If a man is working in an over-warm atmosphere, his heart has to drive blood to the skin to cool it, which should be driven through the brain and muscles; the heart to effect this has to beat much more quickly.

The blood-flow through the hand has been measured and found to increase some five times when a man becomes hot. Quite unnecessary fatigue is then put upon the worker in the effort to keep cool. The expenditure of nervous energy falls on what is called the autonomic (or sympathetic) nervous system, the system of nerves which keeps up the tone, and co-ordinates the work of the bowels, blood-vessels, and glands. It is a serious thing to exhaust this system. In very hot, tropical atmospheres a dry skin from exhaustion of the sweating mechanism always precedes heat-stroke; heat-stroke may be kept away by spraying the subject with water and blowing upon him with fans.

ATMOSPHERIC CONDITIONS

Humid, hot tropical regions are admittedly enervating to white men. The normal metabolism of native university students in Singapore is 1500 calories, not half that of an English student who plays games and keeps himself fit. The tropical native is a very poor worker. Now the k.-t. cooling powers taken indoors, in offices and workshops, in this country are, I find, less than those taken out of doors exposed to wind in humid, tropical countries, such as Sierra Leone, Madras, and Ceylon. In this country, fully exposed to wind, as are shepherds on the hills, fishermen, or sailors on deck, I find the mean monthly dry k.-t. cooling power is in the summer four, and in the winter seven times as great as the ordinary indoor cooling powers. The mean monthly wet k.-t. cooling powers fully exposed to the wind taken in this country are more than twice as great in summer, and more than three times as great in winter as in ordinary workshop conditions. There is, then, a vast difference between the ordinary workshop conditions of outdoor and indoor life. Col. Martin Flack and Miss D. Hargood Ash and I have established the fact that the rate of production of body heat by a man sitting at rest out of doors in ordinary light clothing depends on the cooling power of the air. It is increased by exposure to cold winds 100-150 per cent over the value in pleasant cool days. Under cool conditions there is a relation between the cheek temperature, the dry k.-t. cooling power, and the heat production of the body. If the dry k.-t. cooling power is measured with the surface of the k.-t. at cheek temperature, whatever that may happen to be, then the heat lost by the k.-t. per square cm. per sec. comes out as six to seven times as great as the heat lost by the man per square cm. per sec. (The dry k.-t. cooling power is, in fact, measured with its surface at 36.5°C., and the cooling power at cheek temperature calculated from this by a simple formula.) The relation does not hold good in cool conditions where very warm

ATMOSPHERIC CONDITIONS

clothing is worn, or in warm conditions when there is loss of body heat by increased evaporation from the skin. It is a very important relation to have established, because it demonstrates how exposure to cool moving air out of doors stimulates the greater combustion of food, deeper breathing, and in consequence improves digestion and appetite and invigorates the whole body. The natural impulsion is to keep the body warm and comfortable by muscular exercise, and exercise in its turn deepens breathing, massages the belly organs, and furthers the vigorous circulation of the blood.

Cool surroundings are of the utmost importance to stimulate men to work. On a close, muggy day I find I dismount from my bicycle at the foot of a steep hill, while on a bracing cold day I ride with alacrity to the top. In the case of a particular hill which I used to take every morning, I found the height at which I dismounted, following my natural inclination, was closely correlated with the cooling power.

The New York Commission on Ventilation conducted tests of optional work, for the doing of which a small cash bonus was given. They found 63 per cent more typewriting done at 68° than at 75° F., and of heavy physical work 15 per cent more at 68° than at 75°, and 37 per cent more than at 86° F.

Of 215 records of temperatures in workrooms in New York, 73 per cent were over 73° F. and 29 per cent over 80° F. The loss of efficiency from overheating appears, then, to be enormous.

To know exactly the conditions in these workrooms we require k.-t. readings, but if we assume that in all these rooms the air was still, then the dry k.-t. cooling power stands in relation to the temperature. It is expressed by the formula $H = .27 \theta$, H being the cooling power in milli-calories per sq. cm. per sec., θ the difference between 36.5° C. and the centigrade temperature of the air.

ATMOSPHERIC CONDITIONS

The evaporative power in still air depends on the vapour tension, and this is sure to have been high in these over-warm workshops.

Cool air, even if saturated (but free from mist), has a very low vapour tension, and when raised to body temperature can take up a large amount of water. Warm air saturated, or nearly saturated, has a high vapour tension, and raised to body temperature can take up much less water-vapour.¹ Air at body temperature and saturated can take up none at all, and when air approaches this condition a man can not only do no work, but is in great danger of heat-stroke.

The evaporative and cooling power of the air has a most important influence on the respiratory membrane. I calculate that a man living indoors and doing sedentary work at a temperature of 71° dry bulb and wet bulb 69° F., would evaporate from this membrane 200 grams of water per diem, while if he lived out of doors, took hard exercise, and slept in the open air, with a dry bulb 40° and wet bulb 36·5° F., he would evaporate 700 grams of water, three and a half times more.

If the indoor conditions were wet and dry bulb 85° F., the water evaporated from the breathing passages would be one-ninth of that evaporated by the outdoor man living in the cold air.

The amount of heat lost by the respiratory membrane in evaporating water and in warming up the air breathed would be nearly four times greater in the first case and nearly ten times greater in the second case. Now the heat loss is made good by the flow of arterial blood through the membrane regulated according to its needs, and evaporation is made good by the outflow of lymph from the blood capillaries which percolates through the membrane. The membrane secretes a fluid which washes and cleans the surface.

¹ Each cubic metre of air, saturated with water-vapour, holds at 32° F. 5 grams of water, at 60° F. 13 grams, at 100° F. 45 grams.

ATMOSPHERIC CONDITIONS

On the flow of arterial (oxygen rich) blood, lymph, and cleansing secretion depends the natural defence against infection by the germs of catarrhal disease. How important the secretion is, is shown by the fact that the workers who breathe slight concentrations of fumes which irritate the membrane, and so increase the flow of secretion, are found to be remarkably free from influenza; workers who breathe sulphurous acid, *e.g.* those who burn iron pyrites; workers in cordite factories who breathe fumes containing oxides of nitrogen; commercial gas workers who breathe naphthaline; poison-gas workers.

Coal dust excites secretion, while free silica dust does not. Coal-miners are remarkably free from phthisis, while workers in quartz and granite suffer greatly.

Various smelling-salts, snuffs, sprays, and gargles are used because they keep off infection by exciting secretion. I have tried smelling of bisulphite of soda, a salt which gives off sulphurous acid. It is clean and not unpleasant to smell, and makes the nose run.

Considering the enormous amount of lost time, illness, and death produced by catarrhal diseases and consumption, it is of supreme importance that the environment should be such as to give cool air, the breathing of which keeps up the health of the respiratory membrane. The recent epidemic of influenza is estimated to have killed six million people in India. In a few months it killed as many as the war killed of combatants. Such a pandemic may be successfully met (1) by vaccination with a properly prepared influenza vaccine, (2) by healthy environment and open-air exercise, which prevent deadly secondary infections; (3) by the use of snuffs, smelling-salts, etc., which stimulate the secretion from the respiratory passages, and so prevent infection.

I return to the cooling power of the atmosphere. A

ATMOSPHERIC CONDITIONS

comparison of the rate of heat loss from the body (this is the same as the heat production if the body temperature remain constant) may be made with that from the kata-thermometer.

The heat production of a man at rest, or at work, can be determined from his respiratory exchange. He breathes through a mouthpiece provided with inlet and outlet valves, his nose being clipped. The expired air is collected in a bag and the time spent in breathing into the bag noted. The contents of the bag are pressed through a meter and the volume measured. Samples are taken through a side tube while this is being done and analysed. The percentage of oxygen and carbonic acid are found. The temperature and barometer are read. The composition of the air inspired is known. Thus data are obtained from which the volumes of oxygen used and carbonic acid produced (measured at 0° C. and 760 mm. Hg. pressure) are arrived at. From the data, by means of tables, the energy produced (by combustion of food substances) in the body can be calculated in terms of calories: knowing the weight and height of a man, by means of the Du Bois formula,

$$A = W^{0.425} \times H^{0.725} \times .007184,$$

A = sq. metres. W = weight in kilograms. H = height in centimetres.

the heat loss can be reckoned per sq. cm. per sec. If the external work can be accurately estimated, *e.g.* in lifting the body weight up a known height of stairs, and the increased combustion of food due to the work measured, the efficiency of the body as a machine can be found. This comes out in a man in good condition at about 25-30 per cent, that is to say, when work is done $\frac{1}{4}$ to $\frac{1}{3}$ of the energy is spent in doing external work and $\frac{3}{4}$ to $\frac{2}{3}$ in the production of extra heat which the body must get rid of. The efficiency of highly-trained workers is higher, of untrained people much lower. A fair day's heavy labour is taken at 100,000 kg.m. The best-

ATMOSPHERIC CONDITIONS

trained Alpine climber can do 1,000,000 kg.m. work in one day, but he cannot keep this up. A man cannot digest enough food to yield this amount of energy in one day; he burns up his body fat during such emergency efforts and makes good in the resting days which follow. There is no harm in a strong man occasionally making such calls on his powers, but daily overwork inevitably breaks down the health, e.g. the Hun-driven prisoners.

The heat produced by a man in ordinary clothes doing 100,000 kg.m. work per day can be taken as 3300 calories. I suppose the man weighs 65 kg. and has a surface of 1.9 sq. m. I deduct 570 calories as the normal daily evaporative heat loss of skin and lungs in cool conditions. The required heat loss by convection and radiation from the skin I then estimate to be as follows:

A sleeping period of 8 hours at 51 calories per hour
= 0.74 milli-calorie per sq. cm. per sec.

A sedentary period of 6 hours at 70 calories per hour
= 1.2 milli-calories per sq. cm. per sec.

A working period of 10 hours at 190.5 calories per hour
= 2.79 milli-calories per sq. cm. per sec.

Supposing the man during the sedentary period is in a room at 18° C. and the air is still, the dry k.-t. cooling power is under these conditions 5, that is, four times the above estimated rate of heat loss in man ($1.2 \times 4 = 5$). Experience shows me that 6 is a very common reading in rooms in which sedentary workers are, and that light workers often take their coats off in machine-shops, where the reading also very commonly is 6. A reading of 5 I find is generally associated with closeness.

There is much other evidence¹ with which I cannot now detain you, which goes to show that the dry k.-t.

¹ See my *Report on Science of Ventilation and Open-air Treatment*, published by the Medical Research Committee, 15 Buckingham Street, Strand, W.C.2.

ATMOSPHERIC CONDITIONS

reading indoors should be about four times the rate of heat production of a man to keep him comfortable and free from sweat.

Let it be noted here, however, that comfort does not necessarily secure health. Indoor sedentary workers who require a low cooling power for their work because they do not keep themselves warm by exercise, ought for some two hours each day to expose themselves to open air and the much higher cooling powers out of doors, and take vigorous walking-exercise then.

Now, assuming that the dry k.-t. cooling power should be four times that of the man's required rate of heat loss per sq. cm. per sec., I reach the conclusion that during the man's working hours the dry k.-t. cooling power of 2.74×4 , say 10, is required. From observations made on the metabolism of various workmen by other physiologists, I deduce that their required heat loss by radiation and convection in milli-calories per sq. cm. per sec. during work is as follows :

Tailor, 1.35 ; bookbinder, 1.7 ; shoemaker, 1.8 ; carpenter, 2 to 2.5 ; metal worker, 2.3 ; painter, 2.4 ; stonemason, 2.85 ; man sawing wood, 4.6.

Multiplying these figures in each case by 4, the dry k.-t. cooling powers come out for the

Tailor, 5 ; bookbinder and shoemaker, 7 ; painter, metal-worker, and carpenter, 8 to 10 ; stonemason, 15 ; man sawing wood, 18.

To keep down loss of heat by evaporation, the sub-joined table shows that the tailor will be right in still air at 15° C. and require a breeze of 1 mile an hour at 27° C. and 2 miles an hour at 30° C. The carpenter, metal-worker, and painter will be right in still air at 5° C., and need a wind of 1 mile an hour at 20° C., 2 miles an hour at 25° C., and 9 miles an hour at 30° C. The stonemason, a wind of 1 mile an hour at 10° C., 2 miles an

ATMOSPHERIC CONDITIONS

hour at 15°C. , 9 miles an hour at 24°C. , 20 miles an hour at 27°C. These are low estimates, because the wind increases the cooling of the k.-t. more than it does that of a man. A man's bigger mass shields him. Observations on metabolism in *varying* outdoor, windy conditions show that the dry k.-t. cools, not 4, but 6-20 times faster than a man who is sitting at rest in ordinary light clothing. But the above estimates may suffice, for all we require to do is to prevent uncomfortable sweating, undue waste of energy, and cooling of the body, and give the natural impulsion to work. The following table shows the enormous effect of wind on cooling power :

DRY KATA-THERMOMETER COOLING POWERS IN
MILLI-CALORIES
per sq. cm. per sec.

Temperature of Air.	Still Air.	Wind.			
		0.5 m. per sec., 1.1 mile per hour.	1 m. per sec., 2.2 miles per hour.	4 m. per sec., 8.8 miles per hour.	9 m. per sec., 20 miles per hour.
0°C.	9.8	22.6	27.7	45.6	62.0
5	8.5	19.5	23.9	39.4	53.5
10	7.1	16.4	20.1	33.1	45.0
15	5.8	13.3	16.3	26.8	36.5
20	4.4	10.3	12.5	20.6	28.1
25	3.1	7.1	8.7	14.3	19.5
30	1.7	4.0	4.9	8.1	11.2
35	0.4	0.9	1.1	1.9	2.3

The table illustrates why the caged air of rooms is so debilitating and the free moving air of the exposed places, *e.g.* sea-cliffs and downs, invigorating. From the mean daily and monthly meteorological records of temperature and wind, the dry k.-t. cooling powers can be calculated for exposed places—anemometers are placed on poles above roofs. In this country, as I have said before, the mean monthly dry k.-t. cooling powers

ATMOSPHERIC CONDITIONS

are over 40 in winter and over 20 in summer. In Sierra Leone they vary between 5 and 10. In our rooms and machine-shops they are generally about 6, and in close shops less, but one finds sometimes in big machine-shops near open windows a cooling power nearer to 10 than 5, and men working without complaint. Every effort should be made to secure the highest level of cooling power which the workers can be brought to stand; chilly and less active people must be taught to wear more clothes and not be allowed to shut down ventilation. The foreman who potters about and does no physical work is the last person who should control ventilation. Properly trained assistants are required, appointed to give their whole attention to securing adequate cooling power. It will pay a thousandfold to employ such.

Men who are greatly exposed by day to high cooling powers, e.g. fishermen, Maine lumberers, rightly conserve their body heat by night by shutting themselves up in warm, still air, and so long as they are out on the sea or in camp no epidemic disease is likely to spread by their so doing. Their energy output is so vast by day that they must conserve it by night. On the other hand, sedentary workers should sleep outdoors in sleeping porches, such as are now commonly provided in American houses, so as to secure the beneficial effect of breathing cool air, which, being of low vapour tension, exerts a high evaporative power on the respiratory membrane.

The table shows that by means of fans man can escape from under the curse "In the sweat of thy brow shalt thou eat bread." It will pay the employer to instal these fans, and so regulate the cooling power as to prevent sweating, but not uncomfortably cool the worker, and thus secure the greatest efficiency and output and the least fatigue.

I have tested the above conclusions by getting a squad of soldiers to march in drill order and finding

ATMOSPHERIC CONDITIONS

what dry k.-t. cooling power was required to prevent visible sweating of the forehead. From observations made by physiologists on metabolism during walking, I calculated the heat loss by radiation and convection in milli-calories per sq. cm. per sec. from the skin, deducting 650 calories as the normal evaporative loss per diem. It was :

Resting in bed	0.63 (2.5)
Standing at rest	1.0 (4.0)
Walking 2 miles an hour	2.9 (11.5)
" 3 " "	4.3 (17.0)
" 4 " "	6.3 (25)
" 4½ " "	8.0 (32)

The required dry k.-t. cooling powers are put in brackets, that is, the body heat loss multiplied by 4. Twelve soldiers and a corporal marched in drill order along a level road at 4.3 miles per hour facing the wind. They all sweated. The wet bulb was 5.5°, the dry bulb 7° C., the dry k.-t. cooling power 25. The men were then set to march at 3.1 miles per hour, and the dry k.-t. cooling power now averaged 19. At the end of a mile none sweated. In the first case the required heat loss comes out as $7 \times 4 = 28$; in the second case as $4.5 \times 4 = 18$ milli-calories per sq. cm. per sec. We see, then, that the dry cooling power 4 times that of the estimated heat loss sufficed to stop visible sweating, while cooling power less than 4 times did not do so. Other observations confirmed this experience.

Strenuous workers at hot processes have to alternate short periods of hard labour with resting periods in which they cool off. In the course of a day they really expend quite a small amount of energy. If the need for cooling off were reduced by adequate ventilation, much greater output and shorter working hours would both be secured. They would not, too, want to drink so much beer.

Dr. H. M. Vernon has estimated that in tin-plate

ATMOSPHERIC CONDITIONS

factories a more efficient ventilation increases the output by 12 per cent. over that of the badly-ventilated factory. I believe that by really adequate ventilation a much greater increase in output would result.

In the South African mines and in several mines in this country, the conditions are such that they equal those out of doors on the closest days in tropical humid countries such as Ceylon. It is obvious that men should not be put to work in such conditions. Enormous economic loss results from lack of a little outlay in fans.

Dr. H. M. Vernon has correlated the number of minor accidents which occur in machine-shops with the temperature. A suitable cooling power is required which will keep the fingers warm enough for handling metal work, and at the same time keep the workers vigorous.

The use of small sources of radiant heat, one supplied for each worker and under his or her individual control, is a problem which requires to be studied. The Japanese have done their fine work with nothing but little charcoal stoves at which to warm their fingers.

The heating of the air is a method which inevitably depresses health and spreads respiratory disease, and yet this is a method now largely employed.

The old-fashioned fire-buckets placed about a big lofty shop, with their fumes escaping into the air, tabooed by factory inspectors as most unhealthy, are not as enervating as steam coil and hot-air systems of heating often are. A man could warm his hands and body when he wanted to at these fires, while the sulphur fumes, by slightly irritating his respiratory membrane, may prevent catarrhal infections.

The radiant energy of the fire and the air-currents of the smith's shop with its big openings are ideal, and the smith, employing big muscles and having a big metabolism, is a healthy type of artificer.

ATMOSPHERIC CONDITIONS

It is essential for the health of the nation that the sedentary and the light workers have their condition of indoor caged life mitigated by the daily discipline of open-air exercise. The discipline of keeping fit is a lesson which the nation must learn. At present it does not recognise the need, and is unwilling to practise this discipline.

APPENDIX I.

DIRECTIONS FOR USE OF THE KATA-THERMOMETER
WHICH IS MADE BY HICKS, 8 HATTON GARDEN, E.C.

The Object.—Measurement of the cooling power (or, in a very warm atmosphere, of the warming power) of the atmosphere exerted on a surface (1) dry, (2) wet, at approximately body temperature (36.5°C.) in milli-calories ($\frac{1}{1000}$ gram calories) per sq. cm. per sec.

The dry k.-t. gives the cooling power by radiation and convection.

The wet k.-t. gives the cooling power by radiation, convection, and evaporation.

The difference between the two gives the cooling power by evaporation.

To take the Dry Readings

Heat the bulb in warm water about 80°C. (use a thermos flask) till the spirit rises into the top bulb and the column is free from bubbles. *Never leave the instrument in hot water, for it will burst if the spirit fill the top bulb.*

Allow it to cool, and then repeat, so that the glass may have time to get into equilibrium. A reading taken immediately after the first heating is too rapid.

Wipe the bulb dry and suspend the instrument. It may be held by the stem and well away from the body. Take the time in seconds occupied by the meniscus in falling from 100° to 95° . A stop-watch is best used.

Take three to five readings, and the average of these.

If the temperature of the atmosphere exceeds 90° , the k.-t.

ATMOSPHERIC CONDITIONS

cooling rate is too slow to record; if it is well above 100° , cool the k \acute{a} ta-thermometer, and take the rate of warming from 95° to 100° .

To take the Wet Readings

Warm the bulb with its muslin finger-stall on. Pull the finger-stall tight, gripping the stem near the bulb, and jerk the hand downwards to remove excess of water. Suspend and take the reading. Take three to five readings, and the average of these.

The Factor

The factor of each instrument is inscribed on the stem prefixed by F. In each case divide the factor by the average time of cooling in seconds. The result gives the cooling power in milli-calories per sq. cm. per sec.

To investigate the Conditions of the Atmosphere

- Take
- (1) Wet- and dry-bulb thermometer readings.
 - (2) Wet and dry k \acute{a} ta-thermometer readings.
 - (3) Surface temperature of the cheek.
 - (4) Surface temperature of a piece of black fur.

For (3) and (4) use a sensitive, small-bulbed thermometer, and pass it to and fro over the surfaces. The surface temperature of the cheek indicates the effect of the environment on the worker. That of the black fur indicates the effect of radiant energy on the skin and clothes. If there is no source of radiant energy, the black fur and the air are at the same temperature.

Out of doors take all the readings in the shade, at about head-level, and fully exposed to the movement of the air. Other readings may be taken for comparison (1) in the sun; (2) in the shade screened from wind; (3) at the ground-level, to illustrate any difference of conditions between the head and feet.

Indoors take readings at several places among the workers, so as to estimate the effect of local draught, sources of radiant heat, etc. Readings may also be taken at floor-level, to see if the feet are being cooled more than the head.

To calculate the Dry K.-T. Cooling Power in Still Air, knowing the Temperature

Use the formula $H = 0.27 \theta$,
where θ is the difference between 36.5° C. and the centigrade

ATMOSPHERIC CONDITIONS

temperature of the room. A comparison of the result, with the actual reading found, indicates how still the air of the room is.

To calculate the Wind Velocity from the Dry K.-T. Reading

Use the formula

$$H/\theta = 0.27 + 0.49 \sqrt{V}.$$

H = cooling power in milli-calories per sq. cm. per sec.

θ = difference between 36.5° C. and the centigrade temperature of the air.

V = velocity in metres per sec.

In place of using the formula, the wind may be determined by use of the following table:

H/θ .	Wind. Metres per Second.	Velocity. Miles per Hour.
0.76	1	2.2
0.96	2	4.5
1.12	3	6.7
1.25	4	9.0
1.36	5	11.2
1.82	10	22.4
2.17	15	33.5
2.46	20	44.7

Interpolate by proportional differences.

Example.—Suppose H/θ works out to be .82, then the table:

H/θ	Vel.
.96	2
.76	1
.20	1
Increase	

But .82 is an increase .06 over .76. Therefore the corresponding velocity increase is $\frac{1}{20} \times .06 = .3$. Therefore required velocity is $1 + .3 = 1.3$ metres per sec.

ATMOSPHERIC CONDITIONS

APPENDIX II

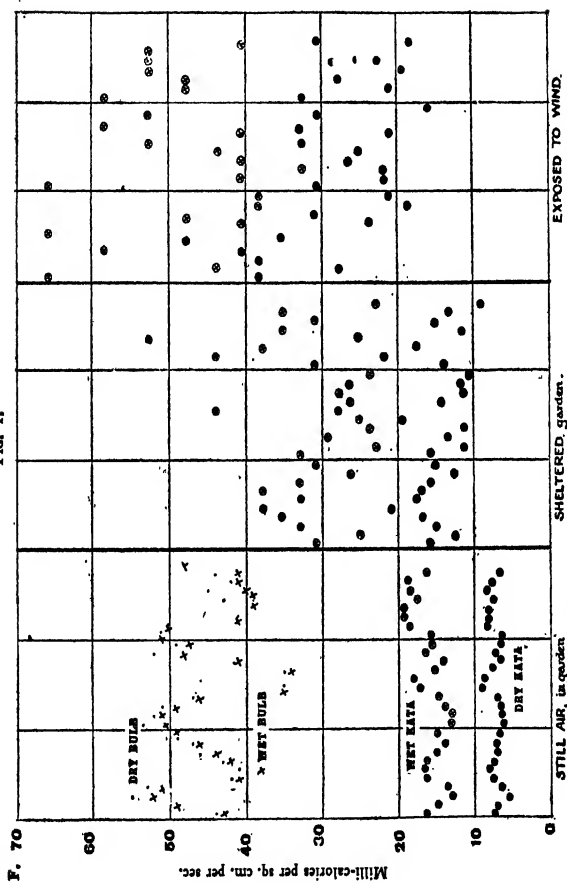
DIAGRAMS

The Figures 1 to 5 give some representative readings of cooling powers and temperatures.

Each dot indicates a reading taken on one day. The heights of the dots above the base-line give the cooling-power values in milli-calories per sq. cm. per sec., the temperatures in degrees Fahrenheit.

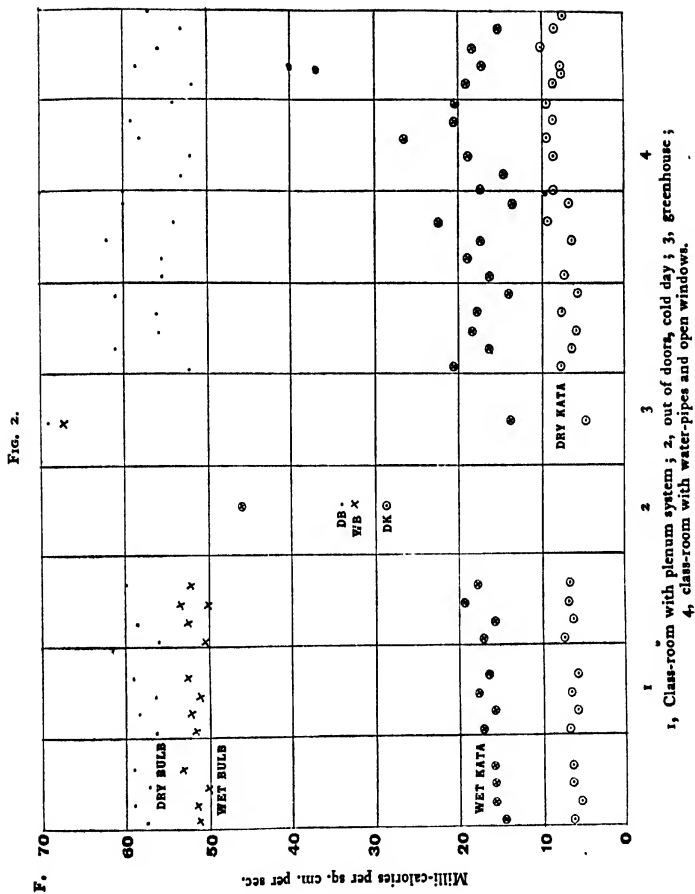
ATMOSPHERIC CONDITIONS

FIG. 1.



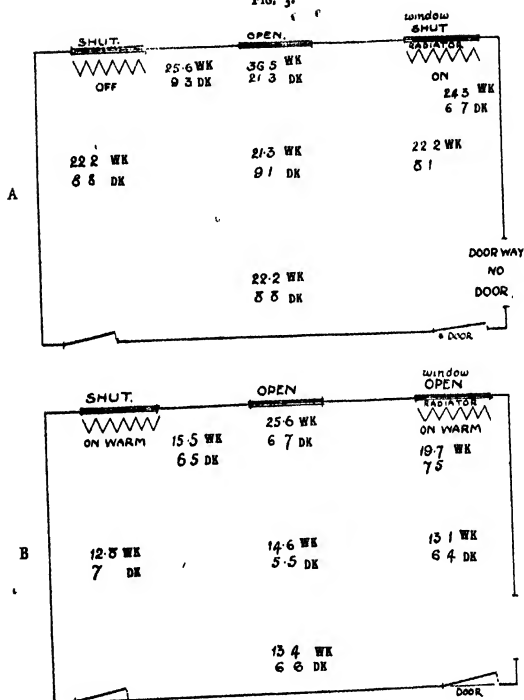
Contrast of readings taken in still air, in sheltered garden, and exposed fully to wind.

ATMOSPHERIC CONDITIONS



ATMOSPHERIC CONDITIONS

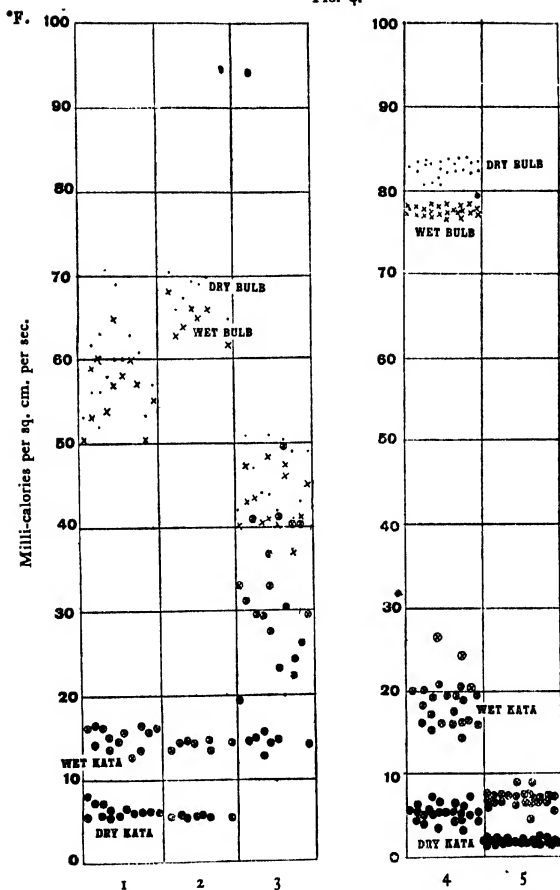
FIG. 3.



A. Class-room with good cooling power.
 B. Class-room with too low cooling power.
 Note the effect of the open window in producing a local draught.

ATMOSPHERIC CONDITIONS

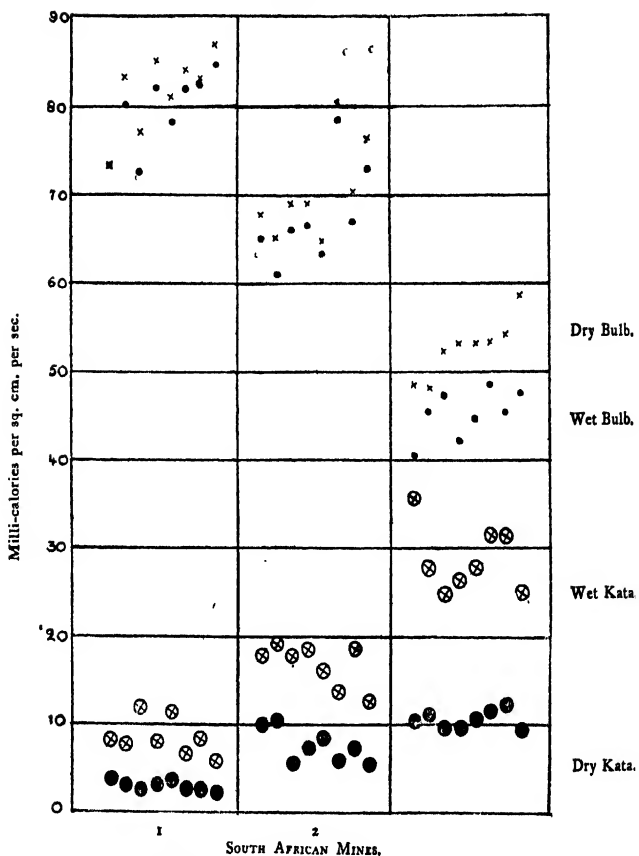
FIG. 4.



1, Spinning mill with local humidification of looms (Scott's method);
2, ordinary humidified spinning mill; 3, out of doors; 4, out of
doors in Ceylon; 5, out of doors in Ceylon in still air.

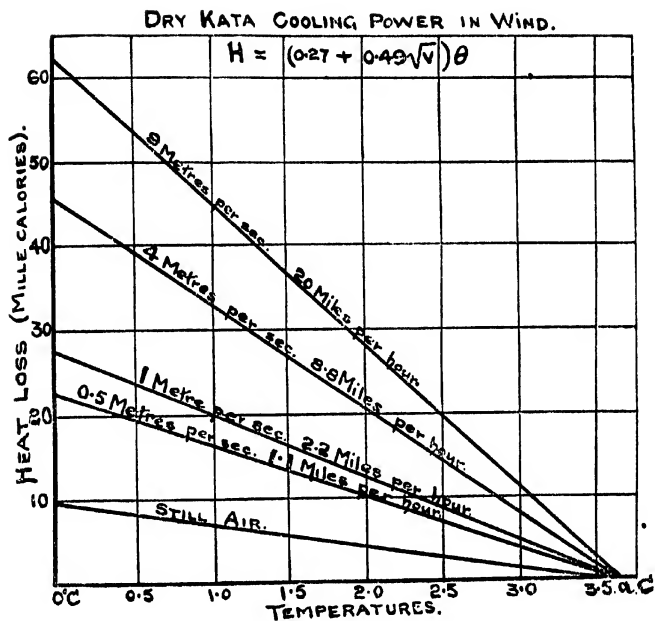
ATMOSPHERIC CONDITIONS

FIG. 5.



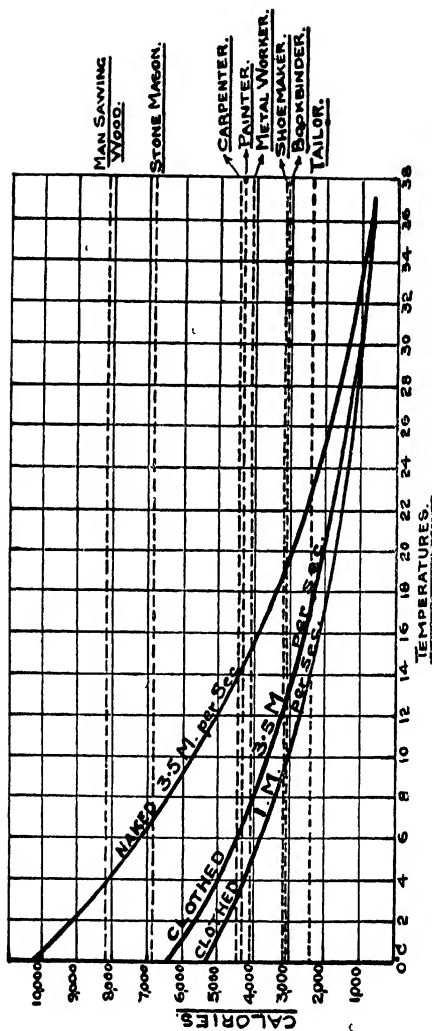
ATMOSPHERIC CONDITIONS

FIG. 6.



ATMOSPHERIC CONDITIONS

FIG. 7.



The rate of heat to be lost by convection and radiation during the working period of various workmen is indicated by the ordinates. The air temperature is plotted out on the abscissa. The curves represent the rate of cooling, in calories per diem, by convection and radiation, of a man naked in a wind of 3.5 m. per sec., clothed, in a wind of 3.5 m. per sec., and clothed, in a wind of 1 m. per sec. The curves suggest that to prevent extra vaporisation the man sawing wood needs to be naked and in a wind of 3.5 m. per sec. at a temperature of 4° C.; the tailor needs to be clothed and in a wind of 1 m. per sec. at 14° C., and to be naked and in a wind of 3.5 m. per sec. at 23° C., and so on.

INDUSTRIAL COUNCILS AND THEIR
POSSIBILITIES

Industrial Councils and their Possibilities

By T. B. JOHNSTON, J.P.

A LECTURE DELIVERED ON MAY 13, 1919.

IN the autumn of 1893, over twenty-five years ago, four manufacturers met at the Cobden Hotel, Birmingham, to discuss the industrial situation, which for the previous three or four years had been disturbed, with strikes and lock-outs throughout the country. In fact, the position then was much the same as it is at the present time. The manufacturers were Mr. R. A. Hadfield, of Hadfields, Ltd., Sheffield (now Sir Robert Hadfield); Mr. T. W. Bushell, of T. W. Bushell & Co., Lithographic Printers, Coventry; Mr. W. L. Robinson, Tar Distiller, West Bromwich; and myself, engaged in the Pottery trade. We unanimously came to the conclusion that an effort should be made to bring employers and employed together in friendly conference in times of peace, in order that they might get to know each other better, by means of an Industrial Union, which should embrace both employers and employed, the objects being :

(1) To promote harmony between employers and employed by affording opportunities for each side to obtain a better understanding of each other's aims and difficulties, and to realise in a larger measure their common interests.

(2) To discuss means by which, without detriment to business, the conditions of Labour and the opportunities of workmen might be improved, and to make known, by a monthly Journal, or otherwise, the results of experiments in this direction.

(3) To foster the establishment, as the way opened, of local branches in the different industrial and agricultural centres.

INDUSTRIAL COUNCILS

We sent invitations to twenty representative Trade Union leaders and twenty employers to a Conference which was held at the Royal Statistical Society's rooms in London, to discuss the suggestion, and the practicability of starting such an organisation. This Conference took place on March 16, 1894, and was attended by well-known employers and Labour leaders. The employers included :

Messrs. Beaufoy & Co., London ;
Messrs. Harrison & Cook, Birmingham ;
Messrs. Pease & Partners, Ltd., Darlington ;
Mr. A. F. Hill, of The Thames Ironwork & Shipbuilding Co. ;
Mr. Daniel Jones, Employers' Section of the Midland Iron & Steel Wages Board ;
Messrs. Hadfield's Steel Foundry, Ltd., Sheffield ;
Mr. W. P. Vickers, of John Whitmore & Co., Worsted Spinners, Leicester ;
Mr. George Matherson, of Clarke, Nicholls & Coombs, London ; and others.

Amongst the representatives of Labour were :

Mr. W. Abraham, Rhondda Miners' Association ;
Mr. C. Hobbs, President, Sheffield Trades Council ;
Mr. Wm. Johnson, Warwickshire Miners' Association ;
Mr. E. Trow, Iron & Steel Trades ;
Mr. John Wilson, Durham Miners' Association ;
Mr. Robert Carter, Secretary, Amalgamated Society of Engineers ;
Mr. Fred Maddison ;
Mr. W. J. Davis, Brass Workers' Union, Birmingham ; and others.

After a two days' discussion the Industrial Union of Employers and Employed was launched. A secretary was appointed, and an organisation set up. The

INDUSTRIAL COUNCILS

Trades Unions took the matter up warmly, and we had support from a number of well-known manufacturers, but the great bulk of employers held aloof, and in the district of which I had charge (Bristol) I was unable to get a single employer to join the Union. In fact, one well-known employer, a friend of mine, replied as follows :

“DEAR JOHNSTON—I cannot conceive what earthly good your Union is going to do, except provide a comfortable berth for the Secretary.”

A number of well-known public men and social reformers supported us loyally, amongst them being Canon Barnett, David Dale, Lord Balfour of Burleigh, Lord Grey, Thomas Hughes, Dr. Clifford, and many others. Matters progressed, and in about twelve months' time we went to our first Congress, which was held in London at the Essex Hall, Strand, Canon Barnett giving a reception at Toynbee Hall on the evening preceding our meeting. That was the first and last Congress that we ever held, for unfortunately the Socialists turned up in strong force, determined to wreck the proposal, and the result was a stand-up fight between the Trade Unionists and the Socialists, whose main objection to the proposed Union was that it would bring about content, whereas what they wanted was discontent. So far as my recollection goes, we employers hardly said a word, and after a most unseemly wrangle the meeting finally broke up in confusion. The employers present, many of whom were more or less lukewarm, said : “What is the good of our wasting time and money in this way ?” and withdrew their support. The Union languished for a year or so afterwards, and finally died out.

Now twenty-five years afterwards, as a member of the first National Council formed, for the last eighteen months I have been sitting constantly on Committees

INDUSTRIAL COUNCILS

and Sub-Committees of our Council with representative workpeople, discussing the problems of our industry in precisely the way that twenty-five years previously we had visioned. I mention this to show how the extremists are responsible for having put progress back at least twenty-five years. If it had not been for the action of the Socialists at that time these National Councils would have taken shape many years ago, and 'probably by this time have been so well established, and in such good working order, that the epidemic of strikes that is now taking place need never have occurred. Let this be a warning to the extremists of to-day, for there is very grave danger of what is happening at the present time undoing all the effort that has been made during the last three or four years to bring about a new spirit in industry.

In the autumn of 1916, as a result of some correspondence that had appeared in our local press, I was asked by Alderman Sheppard, a well-known Labour leader in Bristol and Lord Mayor for the last year, to see if I could get half-a-dozen employers to meet half-a-dozen Trade Union officials and discuss the situation. The result was we met at dinner, and after dinner we had ten minutes each in which to express frankly and freely our views. Shorthand notes were taken of the speeches, and copies sent to all those present. We had another meeting a fortnight later, when we further threshed the matter out. The result was we came to the almost unanimous conclusion that the essential thing to do was to get every man into his Union, and every employer into his Association, and then to govern the industry by a joint body of employers and employed. In other words, we anticipated the Whitley Report.

Shortly afterwards Mr. Arnold Rowntree, through the Workers' Educational Association, invited twenty Bristol employers and twenty Labour leaders to spend

INDUSTRIAL COUNCILS

the week-end as his guests at Shipham, a little village on the Mendips. The result of that week-end Conference was a Report which is now known as the Bristol Report. The practical conclusions we arrived at for Industrial Reconstruction were as follow :

(1) Our industries should be reorganised on a national basis. The unit in this National organisation must be the trade as a whole, not the separate business. The separate employers in each trade should be associated in local Federations of Employers. The operatives in each trade should be associated in the Trade Unions.

(2) Control, in each trade, should be exercised through Joint Committees, especially representative of employers and employed.

(3) The local organisations should in turn be linked to a national organisation of the trade, constituted on similar lines. The several trades organisations should be co-ordinated in a Minister of the Crown responsible for the industrial life of the country as a whole.

(4) Decisions regulating prices, wages, hours and conditions, for the trade as a whole, would, through such an organisation, be arrived at by voluntary agreement between persons actually engaged in the industrial affairs of the nation.

(5) When it could be shown that a certain proportion, say, employers employing 75 per cent of the workpeople and 75 per cent of the operatives, through their representatives, were parties to any such agreement, power should be conferred upon the parties to apply to Government for an Order making its provisions obligatory on all engaged in the trade in question, whether members of the Employers' Federation or Operatives' Societies or not.

(6) A scheme of national industrial reconstruction on these lines is regarded as practicable and urgent.

Shortly afterwards Mr. Arnold Rowntree extended a similar invitation to the employers and operatives in the Pottery trade, for a week-end Conference which was held at Lawton Hall, Staffordshire. In fact, we had three week-end Conferences, one for the operatives

INDUSTRIAL COUNCILS

alone, one for the employers alone, and the third one the employers and operatives combined. Reports were issued of both the employers' suggestions and the operatives' suggestions. *The conclusions arrived at were as follow :*

(1) It was unanimously agreed that the power is needed to compel all firms to observe common rules and standard conditions laid down by the representative associations of the industry. Either

(a) The State should give the force of law to the determinations of a Joint Committee or Committees representative of the Manufacturers' Associations and the Operatives' Unions, or

(b) Membership of Trade Associations and Trade Unions should be compulsory by law on all eligible for membership.

This claim is made, not with the object of abolishing competition and obtaining monopoly, but of restricting competition and diverting it from price to quality and from socially undesirable practices, such as beating down wages, to socially desirable methods, such as improving equipment and organisation. The industry, through its representative organisations, should be able to make common rules dealing with selling prices and conditions of sale, wage rates, and conditions of work.

The essential condition of such an organisation is a new spirit. The industry must be regarded as a department of the national life, existing for the double purpose of serving the community and affording the opportunity of a complete life to all the individuals engaged in it.

(2) This reorganisation would involve

(a) Much greater publicity as to wages, prices, profits, and conditions.

(b) The organisation of the operatives in one Union, or in such a federation of Unions that it would be possible for a manufacturer or association to negotiate with all classes and grades of operatives through one agency. It was agreed that the manufacturers should support and co-operate with the Unions, and that the Unions should lend all the support they could to the Manufacturers' Associations.

INDUSTRIAL COUNCILS

- (c) Machinery by which any grievance could be ventilated without delay. This would involve

(i.) A standing Joint Committee, or Joint Committees, representative in equal numbers of the Manufacturers' Associations and the Operatives' Unions, and,

(ii.) In the larger factories, shop committees, working within lines laid down by the Committee representing the whole trade. Care should be taken to adjust the relations of these works committees to the Unions, so that they should not usurp functions of the Union.

(3) A co-operative effort is needed to increase the economic returns of the industry. Such an increase is a condition of improved relations. Unrestricted competition had been the chief obstacle to better returns in the past. Earnings could be increased at the present rates by bringing up the organisation of all factories to the level of the best, whilst the operatives, if their confidence were won and interest enlisted, could often contribute suggestions of value, and could be relied on to secure the increased output which better organisation made possible. Increased output would pay the manufacturers by reducing the proportion of overhead charges, and would make unnecessary any cutting of rates, a practice which has caused ill-feeling in the past.

(4) The industry needs the Government's assistance to give greater security—

- (a) To make full and regular employment possible ;
- (b) To encourage enterprise ; and
- (c) To make experiment on a large scale practicable.

(5) The Government should also alter its practice in the matter of contracts, and

- (a) Withdraw its opposition to every sort of agreement among manufacturers as to prices, contenting itself with requiring evidence that the costs of the industry justify the prices asked ;
- (b) In placing contracts, allow for the better conditions of work which English law requires in English factories as compared with foreign factories ; public authorities in England should be prepared to pay the higher prices which the higher standards cause ;

INDUSTRIAL COUNCILS

- (c) Lessen the term of its contracts, and give up the practice of specifying goods so different from ordinary market demands that Government contracts cannot be fitted into the ordinary work of a firm.

It was thought that representatives of Government departments would profit by attendance at such conferences as the present, since they badly need educating in the conditions and difficulties of this (and every other) industry. Association in the trade is needed to secure fair treatment from the Government and the right to manage the affairs of the industry without the interference of people who do not understand it.

(6) There is room for a great deal of inquiry and research, which might be done partly by the Government, but must largely be a co-operative effort of the people in the industry. The chief objects would be—

- (a) Full and reliable statistics of wages, profits, markets, costs ; an essential first step is the devising of scientific and practical costing systems. The collection and analysis of disease and mortality statistics is equally important ;
 - (b) A more thorough knowledge, based on both laboratory and practical experiments, of the processes and materials of the manufacture ;
 - (c) The discovery of more healthy processes and materials.
- (7) A revision of wage rates is needed and the establishment of new lists based on uniform and systematic principles, and subject to no stoppages or deductions.
- (8) A reform of the apprenticeship system is needed.
- (9) An educational campaign is needed to secure better observance of precautions against disease ; methods need to be devised by which compensation charges could be placed on the industry as a whole, instead of on particular firms.
- (10) Great care in the selection of foremen and managers is needed, to ensure that no one shall be appointed who does not possess both technical knowledge and the requisite moral qualities. An operative should never be dismissed without a hearing by the head of the firm.

The result of that meeting, or series of meetings, was that we fixed up our National Council for the Pottery Industry, with the following constitution :

- (1) *Membership*.—The Council shall consist of an equal

INDUSTRIAL COUNCILS

number of representatives of the Manufacturers and the Operatives ; the Manufacturers' representatives to be appointed by the Manufacturers' Associations in proportions to be agreed on between them ; the Operatives' representatives by the Trade Unions in proportions to be agreed on between them. The number of representatives on each side shall not exceed thirty.

Among the Manufacturers' representatives may be included salaried managers, and among the Operatives' representatives some women operatives.

(2) *Honorary Members.*—The Council to have the power to co-opt Honorary Members with the right to attend meetings or serve on Committees of the Council, and to speak, but not to vote.

(3) *Re-appointment.*—One-third of the representatives of the said Associations and Unions shall retire annually, and shall be eligible for re-appointment.

(4) *Officers.*—The Officers of the Council shall be :

(a) A Chairman and Vice-Chairman. When the Chairman is a member of the Operatives, the Vice-Chairman shall be a member of the Manufacturers, and *vice versa*. The Chairman (or in his absence the Vice-Chairman) shall preside at all meetings, and shall have a vote, but not a casting vote. It shall always be open to the Council to appoint an independent Chairman, temporary or otherwise.

(b) Such Secretaries and Treasurers as the Council may require.

All Honorary Officers shall be elected by the Council at its annual meeting for a term of one year, and, subject to the condition that a Chairman or Vice-Chairman from the said Associations shall be succeeded by a member of the said Unions, shall be eligible for re-election. The Council may from time to time fix the remuneration to be paid to its Officers.

(5) *Committees.*—The Council shall appoint an Executive Committee, and Standing Committees, representative of the different needs of the industry. It shall have power to appoint other Committees for special purposes, and to co-opt such persons of special knowledge, not being members of the Council, as may serve the special purposes of these Committees. On all Committees both Manufacturers and Operatives shall be equally represented. The Minutes of all Committees shall be submitted to the National Council for confirmation.

INDUSTRIAL COUNCILS

Each Committee shall appoint its own Chairman and Vice-Chairman, except in the case of the Finance Committee, over which Committee the Chairman of the National Council shall preside.

(6) *Finance*.—The ordinary expenses of the Council shall be met by a levy upon the Manufacturers' Associations and the Trade Unions represented. Special expenditure shall be provided for by the Finance Committee.

(7) *Meetings*.—The ordinary meetings of the Council shall be held quarterly. The annual meeting shall be held in January. A special meeting of the Council shall be held on the requisition of ten members of the Council. Seven days' notice of any meeting shall be given. Twenty members shall form a quorum. Committees shall meet as often as may be required.

(8) *Voting*.—The voting upon all questions shall be by show of hands, and two-thirds majority of those present and voting shall be required to carry a resolution. Provided that, when at any meeting the representatives of the Unions and the Associations respectively are unequal in numbers, all members present shall have the right to enter fully into discussion of any matters, but only an equal number of each of such representatives (to be decided amongst them) shall vote.

The objects of our National Council are :

The advancement of the Pottery industry and of all connected with it by the association in its government of all engaged in the industry.

It will be open to the Council to take any action that falls within the scope of its general object. Its chief work will, however, fall under the following heads :

- (a) The consideration of means whereby all Manufacturers and Operatives shall be brought within their respective Associations.
- (b) Regular consideration of wages, piecework rates, and conditions with a view to establishing and maintaining equitable conditions throughout the industry.
- (c) To assist the respective Associations in the maintenance of such selling prices as will afford a reasonable remuneration to both employers and employed.
- (d) The consideration and settlement of all disputes between

INDUSTRIAL COUNCILS

different parties in the industry which it may not have been possible to settle by the existing machinery, and the establishment of machinery for dealing with disputes where adequate machinery does not exist.

- (e) The regularisation of production and employment as a means of insuring to the workpeople the greatest possible security of earnings.
- (f) Improvement in conditions with a view to removing all danger to health in the industry.
- (g) The study of processes, the encouragement of research, and the full utilisation of their results.
- (h) The provision of facilities for the full consideration and utilisation of inventions and improvements designed by workpeople, and for the adequate safeguarding of the rights of the designers of such improvements.
- (i) Education in all its branches for the industry.
- (j) The collection of full statistics on wages, making and selling prices, and average percentages of profits on turnover, and on materials, markets, costs, etc., and the study and promotion of scientific and practical systems of costing to this end.
All statistics shall, where necessary, be verified by Chartered Accountants, who shall make a statutory declaration as to secrecy prior to any investigation, and no particulars of individual firms or operatives shall be disclosed to any one.
- (k) Enquiries into problems of the industry and, where desirable, the publication of reports.
- (l) Representation of the needs and opinions of the industry to Government authorities, central and local, and to the community generally.

That National Council has now been working for over eighteen months, and I think every one is agreed that the work it has done has been most valuable. The almost daily contact between employers and operatives on the various Committees has educated both sides in a way which amply justifies the hopes of those who have been responsible for initiating the Whitley Councils. There is one special feature of our Pottery

INDUSTRIAL COUNCILS'

Council which no other Council has so far adopted, to which I particularly desire to call your attention, for in my opinion it is fundamental to the real success of these Councils. You will notice that under Clause (j) we are disclosing the average wages and the average profits on the turnover. I attach the greatest importance to the disclosure of these facts. Let employers and employed know the facts, and they can be trusted to deal with them in a common-sense way. It is precisely because Labour at present does not know the facts, and because the only way of ascertaining what wages an industry can carry is by making periodical demands after the manner of the Income Tax Collector, that friction arises. In truth it is not possible to conceive a system, or want of system, better calculated to cause trouble and unrest. The first essential to a better understanding between Capital and Labour is that all the cards should be laid on the table, and all the facts known, and that can only be done when the industry is thoroughly organised and employers and workpeople belong to their respective organisations.

Now I may say at once that in my opinion we should never have got the agreement to disclose our profits through the various Associations in the industry if it had not been for the American Government. Now this seems a curious thing to-day, but it is the fact. In 1913, when the Democrats came into power in America, they reduced the tariff on Pottery into the United States from 60 per cent to 40 per cent. The American manufacturers complained that they could not possibly compete with the low-priced labour of Europe with such a reduction in the tariff. The reply was: "That may be so, but we shall want more than your word for it; are you willing to throw the whole of your industry open for investigation, in order that we may ascertain all the facts, and what the costs of production are? If you agree to this we

INDUSTRIAL COUNCILS

will appoint a Commission to enquire into all the facts, and having ascertained them we will send the Commission to Europe to find out the costs of production in the European countries." The American manufacturers agreed to this ; a Commission was appointed, and a very capable Commission it must have been. They probed the industry thoroughly, and ascertained the average cost of production, and having done this they came to England and desired to make a similar investigation into our industry. We naturally demurred at showing them all our figures and results. Their reply was to this effect : " Of course, we have no authority to compel you, and if you refuse to give us what we ask for you are entirely within your rights. The facts, however, are these, the American manufacturers complain that they cannot compete with your low-priced labour compared to theirs with a 40 per cent tariff. The only way in which we can ascertain whether their contention is right or not is by knowing your cost of production. If you refuse to give us the figures we have no answer to make to the American manufacturers' contention, and the result will be the tariff will have to go back to 60." Well, gentlemen, we were thus between the devil and the deep sea, and the result was we had to let them make their investigations, and they arrived at our cost of production on the same lines as they arrived at the American costs. They then went to Germany and Austria, and did the same thing there. They were in France when the war broke out, and we have not got the French figures, but in a comparatively small book we have a complete history, on absolutely scientific lines, of the costs of production in the United States, England, Germany, and Austria. On the next page are given the final results.

INDUSTRIAL COUNCILS

COST OF PRODUCTION, BY SPECIFIED ITEMS, AND NET EARNINGS PER
100 OR NET VALUE OF PRODUCT, IN AMERICAN, ENGLISH, AND
GERMAN EARTHENWARE ESTABLISHMENTS.

Items.	United States.	England.	Germany.	Austria.
Materials	20·05	28·74	14·27	17·14
Labour	47·94	40·84	44·04	39·78
Kiln Fuel	8·84	8·19	8·94	9·40
Power, Heat, and Light	1·13	3·05	3·40	3·52
Office and General Expenses	3·07	3·07	4·08	6·04
Fixed Charges	·54	1·85	4·02	2·36
Cost of Packing	5·11	6·58	4·45	7·28
Selling Expenses	4·71	1·73	6·59	2·34
Total Cost	89·39	94·05	89·79	87·86
Net Earnings	10·61	5·95	10·21	12·14

Note.—Net earnings include interest, depreciation, and profit.

You will see from these figures that in the United States the net earnings are 10·61, in Germany 10·21, in Austria 12·14, and in England 5·95. These are net earnings on the turnover. In the American report they find that the average rate of turnover to capital in America is as 100 is to 111 ; practically the turnover and capital are equal. In England this would be almost the same. So you will see that whilst the net earnings in the United States, Germany, and Austria are reasonable returns, the English return was absolutely unreasonable. You will also notice that in the United States Labour and Capital between them took 58·15 of the total value of the product ; in Germany they took 54·25 ; in Austria, 51·92 ; whilst in England Labour and Capital between them only earned 46·79. In America out of every £100 worth of goods produced 58·15 was available for division between Capital and Labour ; in Germany 54·25 was likewise available, and in Austria 51·92, but in England only 46·79, showing clearly that the goods in England were being sold at a price which was not fairly remunerative. I firmly believe that if a similar investigation

INDUSTRIAL COUNCILS

had been made in 1913 in our staple trades similar results would have been shown. The policy of Free Trade does not permit of a reasonable remuneration either to Labour or Capital, and it is obvious that if Labour is to be better paid the consumer must pay a higher price. The policy of looking after the consumer and letting the producers look after themselves had before the war been carried too far. *Hinc illae lacrimae*. As a result of the conditions brought about by the war the pendulum would appear to have swung too much the other way, and now it is the consumers who are suffering. What is wanted is a fair and square deal between Capital, Labour, and the Consumer. Now is it not possible to bring about such a condition of things that the balance may be held fairly between the three parties? I think it is, and I claim that under the scheme which is now in force in the Pottery trade this will be brought about. By disclosing our profits we Pottery manufacturers have absolutely put it out of our power to make undue profits by either sweating labour or fleecing the consumer. On the Statistical Committee of our National Council we are now discussing what figure shall be taken as representing a reasonable profit on the turnover. If profits are made exceeding this figure it will become a question whether they shall go to labour in the shape of increased wages, or whether they shall go to the community in the shape of reduced prices. There ought, therefore, to be some supreme authority, which I suggest should take the form of an Industrial Appeal Court, on the lines of our present Law Courts, and no agreements made between Capital and Labour as regards the disposal of these surplus profits should become operative until ratified by such Court. This Court, having all the data available in the various industries as regards wages, conditions, etc., would be in a position to give a just decision.

INDUSTRIAL COUNCILS

I must further point out and emphasise that a vital element to the success of these proposals is that all employers and all workpeople should be in their respective organisations, and that these Councils must have executive powers. In paragraph 23 of the Whitley Report the Committee apparently recognise this. The paragraph is as follows :

It may be desirable to state here our considered opinion that an essential condition of securing permanent improvement in the relations between employers and employed is that there should be adequate organisation on the part of both employers and workpeople. The proposals outlined by the Joint Corporation throughout the several industries depend for their ultimate success upon there being such organisation on both sides ; and such organisation is necessary also to provide means whereby the arrangements and agreements made for the industry may be effectively carried out.

Herein lies the crux of the whole matter, and it must be faced, otherwise the suggestions of the Committee mean little more than setting up Conciliation Boards, which have been common in most industries for many years. We cannot shut our eyes to the fact that in some form or other a measure of compulsion will be necessary in order to bring about effective organisation, and by " effective " I mean organisations which shall embrace the whole of the industrial parties ; without such effective organisations all the thought and work which have been put into this problem will be more or less valueless. At present these Councils are purely voluntary associations, and it is obvious that one important manufacturer remaining outside of the organisation might wreck the whole proposal. How would it be possible to obtain proper returns for the industry if some manufacturers refused to give them ? As a result of many Conferences between employers and employed during the last few months I believe the feeling is growing that the State should set up some

INDUSTRIAL COUNCILS

form of machinery to secure that, at any rate in our staple trades, every worker should belong to his Trade Union and every employer to his Trade Association, and if these Councils are to be the success that it is possible for them to be the Government must seriously consider the advisability of taking some action to bring this about. Under these Councils we are endeavouring to make the industry the unit instead of individual firms, and this will be impossible unless we get all manufacturers and all operatives into their respective organisations. Three ways occur to me by which this end can be attained :

(1) In our staple trades membership of Trade Associations and Workers' Unions might be made compulsory by law on all eligible for membership.

(2) The State might give a legal status to both Trade Associations and Trade Unions, and give the force of law to all determinations of a Joint Committee or Committees representative of the Manufacturers' Associations or the Operatives' Unions, making the decisions binding by law on all engaged in that section of the industry, whether members of the respective organisations or not.

(3) The Government might announce that they are prepared to grant a Charter to any industry, or section of an industry, in which the Masters' Federation employ 75 per cent of the workpeople, and the Trade Union represents 75 per cent of the operatives, providing that application is made jointly by the two parties, which Charter shall, *inter alia*, make it illegal for any one but members of the Trade Union to be employed in that industry, or for any employer to operate unless he is a member of the Trade Association.

The first proposal is the simplest, and goes to the root of the matter, but I think we may rule this out of court at the present time as too drastic a step to take all at once.

The second suggestion would be equally effective, but it would involve the giving up by the Masters' Associations and the Trades Unions of the privileged

INDUSTRIAL COUNCILS

position that they at present enjoy under the Trades Disputes Act. The advantages gained, however, would in my opinion amply compensate for this. Another objection would be that while all employers would probably be induced to join their Trade Associations under such a law, it is questionable whether the suggestion would not tend to a weakening of the Trades Unions, owing to the fact that there would be no inducement for an operative to join the Union seeing that he would be able to obtain the same advantages whether he joined or not.

The third suggestion seems to me the best and most practicable at the present time. In the first place, the Government could put forward such a proposal without taking any great responsibility. They would not move until requested to do so by three-fourths of both employers and operatives in the trade. They would simply offer facilities. If no trades availed themselves of these facilities no harm would be done. If, on the other hand, one, two, or half-a-dozen trades applied for Charters a very useful social experiment could be made, which, if successful, would go a long way to solving the problems affecting industry.

We have to bear in mind that we must take into consideration, not only the interests of the employer and the workpeople, but also the interests of the State as representing the community. Therefore it will be necessary, if such a close corporation of employers and operatives is to be legal, that proper safeguards should be made in the interests of the consumer, and it seems to me that this Charter provides the very means for doing this. Provisions could be inserted such as the following :

(1) A State representative should attend every meeting of the Industrial Council and its Committees and Sub-Committees. In this way the Government would be in continuous touch with the industry, and if anything contrary to public policy

INDUSTRIAL COUNCILS

was likely to come about the State would have immediate information of what was going on, and could take steps accordingly.

There would be the added advantage that this representative would form a close link between the industry and Government Departments, which would be of the very greatest benefit to the industry. By attending these meetings regularly this representative would obtain such complete knowledge of the trade as would be impossible under any other conditions.

(2) The Charter would also insist on full publicity of all the facts connected with the trade, such as wages, hours of labour, conditions, prices, cost of production, and profits, and if necessary (and I am inclined to think that this would be highly desirable) the Government itself should undertake the collection of all these statistics, and issue annually such a Report as has been done by the American Government on the Pottery industry. If this were done in all the staple trades throughout the country, and we could thereby get a knowledge of the real facts in every industry, incalculable good would result.

Any other conditions that might be considered necessary for the protection of the consumer could be embodied in the Charter, and thus provide for full State supervision, which we must all admit is necessary in the interests of the community. The industry as a whole will be given great powers for good or evil, and it is therefore necessary that there should be State supervision.

As time goes on and things develop the real problem will emerge, which is not so much one of Labour against Capital, but of one set of producers against another set of producers, and therefore it seems to me to follow logically that there must be some supreme power that will settle the relative rights of each industry. The several National and Industrial Councils should therefore be co-ordinated under a Minister of the Crown responsible for the commercial and industrial life of the country as a whole. In other words, this would mean compulsory arbitration, not so much between Capital and Labour as such, but

INDUSTRIAL COUNCILS

between industry and industry. It would be intolerable, for instance, if the miners through the strength of their Association were to continue to force up the price of wages, and the coal-owners, rather than resist these demands, acquiesced and met them by increasing the price of coal. It is obvious in a case like this that every other section of the community would suffer. The same thing of course would apply equally to other industries. Therefore, it seems logically certain that as the situation develops something in the nature of what I have indicated above will come about.

It does seem to me that the idea of a Charter provides the means whereby we can, gradually and systematically, without any radical change, bring all our workpeople and all our employers into their Associations while at the same time safeguarding the interests of the consumer.

In our trade, for instance, supposing such a Charter was obtainable, in all probability the Sanitary section, where more than 75 per cent of employers and operatives are in their Associations, would immediately apply for a Charter. The China trade might do the same. In the Tile section, although more than 75 per cent of the employers are in their Association, nothing like that number of operatives would be in their Union; the Tile section, seeing that the Sanitary and China sections had already obtained Charters, would, I think, naturally exert every effort to place themselves in such a position as would qualify them for making an application. Similar efforts would be made in the General Earthenware trade to this end.

So that the movement would be a progressive one, and in course of time would result in all industries coming under the same method of control, and we should by that means be able to obtain a thoroughly organised State in which the interests of all parties could be fairly and equitably dealt with. It is not

INDUSTRIAL COUNCILS

too much to hope that if such a state of things did eventually come about, that just as we have organised our industries nationally we might also be able to organise them internationally.

It does seem to me that a Charter on the lines suggested would practically overcome all our difficulties. What appeals to me in the matter is that the Government takes no real responsibility ; it would not move until 75 per cent of all engaged in a trade, or section of a trade, requested it to do so. The Government would simply grant facilities. There should not be much difficulty in passing such an Act through Parliament. The fundamental thing, if we are going to organise our industries successfully, is to get every man into his Union, and every employer into his Association, and the Charter I have suggested appears to be by far the best method of obtaining the desired result, for in this Charter it would, as I have said above, be laid down what conditions are considered necessary to protect the consumer. There should also be safeguards provided by which any one in the industry who feels aggrieved by any decision of the Council should be able to appeal to an independent arbitrator.

When once our trades are properly organised on this basis many things become possible. The various National Councils would have control of production at the source, and it would be quite possible for them to fix the prices, based on the cost of production, of the main staple commodities to the ultimate consumer, providing by means of discounts reasonable profits for the distributors, both wholesale and retail, in the same way as is now done in various Trusts, the Tobacco trade, for instance. There would, however, be this very great difference, that while in these Trusts there is no means of ascertaining whether the base price is a reasonable one or not, the full publicity given as to

INDUSTRIAL COUNCILS

the cost of production, profits, wages, etc., by the National Councils would disclose the facts.

Under a system such as I have outlined :

(1) The best wages an industry could carry would be ensured to the workers.

(2) Economic security and a reasonable return would be afforded to the average manufacturer.

(3) Distributors, both wholesale and retail, would get a reasonable reward for their services.

(4) The consumer would eventually pay the price he ought to pay, neither less nor more.

(5) Initiative and enterprise would not be interfered with in the least, rather would they be encouraged.

The enterprising manufacturer who introduced new methods, or new processes, which increased his profits, would obtain the reward of his enterprise, the increased profits that he made as a result going to swell the average profits of the industry, and as this new machine, or invention, or new process, became more and more general throughout the trade, so the average profits would tend to increase, and would thus eventually go to labour in the shape of increased wages, or to the community in the shape of reduced prices.

This may seem Utopian, but speaking now with thirty-five years' practical experience I feel convinced that it is practically possible, providing only that the National Councils become effective instruments.

We may then go on still further. If we have the various industries of this country organised under various National Councils, in the present state of economic conditions the world over it is fairly certain that the same methods would be followed by other countries. It would then become a comparatively easy matter to have agreements with the National Councils in England and the National Councils in other countries both as regards wages and prices, thus fulfilling one of the main objects of the Labour Party,

INDUSTRIAL COUNCILS

and substituting co-operation for competition all along the line. After all this is only what is now being done by many large Trusts, which arrange internationally prices, spheres of influence, etc. The tariffs should then be used only in the first place to stop dumping, and in the second place to equalise the conditions brought about by the difference in the rates of wages in the various countries, thus giving to every nation equality of opportunity. The nineteenth century was a century of competition ; the twentieth century must be one of co-operation if the proposed League of Nations is to materialise. In point of fact what I have outlined above is a system of National Kartels controlled democratically, with all their transactions carried out in the light of day. If these National Kartels once become firmly established the main idea of the Socialists would have been carried out, only without the blighting and sterilising effects of State management. We should practically have adopted the socialist idea, but for State management we should have substituted management by National Industrial Councils, all the members of which thoroughly understood the industry in which they were engaged.

In putting forward this last suggestion I am of course looking far into the future, but I am convinced that this end is not unattainable in the long run. The first step to take, however, is for the Government to take powers to grant to those trades which are ready for it, and which desire it, a Charter on the lines I have suggested.

The Prime Minister in his recent speech to the Provisional Joint Committee appointed by the Industrial Conference asked for a plan which other nations who were looking to Britain for a lead might copy. The Pottery industry firmly believe that they have produced such a plan, fair and equitable alike to the employers, the workers, and the consumers, and one that

INDUSTRIAL COUNCILS

is immediately practicable. I sincerely trust that you will give it your most careful and sympathetic consideration.

New times demand new measures and new men ;
The world advances, and in time outgrows
The laws that in our fathers' days were best ;
And, doubtless, after us, some purer scheme
Will be shaped out by wiser men than we,
Made wiser by the steady growth of truth.

QUESTIONS PUT AT LECTURE DELIVERED AT MANCHESTER ON MAY 13, AND REPLIES TO SAME

- (1) How far does your system of National Councils, as adopted in the Pottery Trade, go in opposition to the movement on foot, which has considerable support, for management from the bottom ?

We do not believe in management from the bottom. We claim that our plan is highly democratic, all the members of the National Council, whether employers or employed, being elected by ballot by their respective organisations.

- (2) The plan you suggest would rule out all new-comers into an industry, which would be fatal to initiative and enterprise.

We exclude no new-comers from the industry. All that is necessary is that the party in question should belong to our Association and respect its rules. In return for this he has many advantages. In the first place he has an enormous amount of information given him ; all Minutes and Reports are placed at his disposal, and he is able to gain in a comparatively short time experience that would otherwise take him years to acquire. He obtains knowledge of the wages he should pay in each department, and he obtains knowledge of the prices which are ruling in the various markets, in addition to which he would have lists of Merchants, etc. In fact he would obtain the accumulated experience of the whole trade instead of having to find it out for himself, and to pay for it.

INDUSTRIAL COUNCILS

- (3) Is it reasonable to base the wages of an industry on the average return ?

Most decidedly. The questioner seems to imply that the average Britisher, whether he be workman or manufacturer, is a fool. I would only point out that that can hardly be the case, otherwise we should not have obtained the present position we hold amongst the nations of the world. Spencer, Mill, and their school, with their doctrines of the survival of the fittest, devil take the hindmost, and the weakest to the wall, attempted to organise society on the basis of the superman. The Socialists have reacted from that conception, and they are attempting to organise society to suit the needs of the incompetent. Truth, as ever, lies in the *via media*, and the idea underlying our Pottery plan is that society should be organised so that the *average* workman may obtain a reasonable wage, and that the *average* employer may obtain a reasonable profit, leaving the way still open for those who are above the average to obtain the reward of their initiative and foresight.

- (4) What provision have you made for the large class of technical men to be represented on the Council ?

You must bear in mind that these Councils are recent growths, and it is quite true that we entirely overlooked the claims of the technical men at the initiation of the Council. The matter, however, has been gone into since then ; there is now an Officials' organisation in course of formation, and the question of what part they shall take in the National Council is under consideration.

TRAINING FOR
FACTORY ADMINISTRATION

Training for Factory Administration

By ST. GEORGE HEATH

AS the phrase "Training for Factory Administration" is, so far as the writer knows, a phrase which has never been used before, it may be well to start by a careful definition. The word "training" has been used rather than "education" to call attention to the fact that what is meant is a special training coming after, and following on a general education. When we talk of the training of a teacher we do not mean the general education which he receives, but a special course of education coming after his school, and in many cases his University, education, in which he is to acquire the art of teaching. So too, in this paper, by the training of a Factory Administrator is meant a course of instruction following upon the general mental training and discipline of school. The word "factory" instead of "business" has been chosen because this latter word is used in so many senses, and covers so wide a field. A business man may mean a financier, a merchant, a broker, or factor, or in short, almost any one who is neither an artisan, a shopkeeper, nor a professional man. The use of the word factory makes it clear that we are dealing with a problem that arises when a number of people are working together, usually with machinery, in order to produce certain common or similar products, or to render a certain service. At the same time the word is used with reluctance, and only because of the absence of a better word, because under the word "factory" we shall have

FACTORY ADMINISTRATION

to include such enterprises as a tramway or dock undertaking, as well as a railway or shipping company, or a firm of builders. What is essential for our definition is not the presence of machinery, but the presence of a large number of people, some controlling and some being controlled, and all working to produce some common object, or to render some similar service.

The reason for the use of the word Administrator will not become fully clear until the end of the paper; but at the outset we may notice that it is meant to exclude the buying of raw materials, the marketing of the finished product, and the actual detailed supervision of the technique of material production such as, for instance, is required in the works chemist, the handling of people as opposed to the handling of material products, and the framing of these common rules and regulations which are so indispensable in any large scale undertakings. On the other hand, the functions of the Factory Administrator are meant to be wider than those of the Works Manager, in the sense, for instance, in which the phrase is used in Mr. Sidney Webb's book on the *Works Manager To-day*.

Factory Administration implies a close relationship of five classes of persons, namely the workpeople, including the Trade Unions, the other people who are included in the management, the heads and directors of other factories in the same industry, the State and Municipal officials, and the outside public. Under the heading of Factory Administrators we mean to include all those persons above the rank of foremen who have to make decisions, from the heads of departments up to the directors.

It is of course to be borne in mind that the same person may be concerned in buying and marketing or in supervising technical processes, as well as in administration in the sense defined above. For instance, in the case of municipal undertakings, the tramway

FACTORY ADMINISTRATION

manager, or the gas manager, not only has to supervise the actual technique, but he is often trusted with very wide responsibilities in the management of the staff and of labour. Similarly, the director of the company supervises the actual technical or scientific processes, and at the same time supervises the staff, and sits as the representative of his firm upon the Executive Committee of the Employers' Association, or in certain industries is a member of the State Trade Board. As will be seen later, when we talk of the training of a Factory Administrator, we mean something additional to the scientific or technical training which a man receives in chemistry, electricity, metallurgy, or the like.

Perhaps we can throw further light upon the word "Administration" by a comparison of the administration of a modern business with the administration of a State Department by the modern civil servant. In making this comparison, the writer is conscious that in certain fundamental matters Civil Service administration will always remain distinct from factory administration, and the two are here brought into juxtaposition only with the view to emphasising certain similarities.

PART I

THE MANAGEMENT OF A MODERN FACTORY

The management of a modern factory is tending more and more to resemble in certain of its features the administration of the Civil Service. With the growth in size of the modern Civil Service, and with the widening of its scope, it has become increasingly necessary for the Civil servant to be able to work in close co-operation with his superiors and his equals, and to be able to put his mind into the common stock,

FACTORY ADMINISTRATION

and to learn the art of giving and taking. Secondly, he has to handle an ever-growing number of subordinates, to control their work, and at the same time to make them feel that they are partners with him, and that the success of the department depends primarily upon their efforts. Further, and as a part of this, he has constantly to frame common rules and regulations, and at the same time to be always on his guard lest these rules and regulations should destroy individual initiative, and create disaffection or, in more familiar language, to avoid the danger of "red tape." Lastly, he has to keep closely in touch with public opinion, to feel the pulse of those whom his administration will affect outside the Civil Service, *i.e.* the community as a whole, and to understand what are the possible changes in human nature upon which he can rely at any given moment.

In the case of a few departments, such as the Post Office and the Admiralty, there is also the still more difficult problem of the management of labour, of Trade Union organisation, and of all the vexed relationship of capital and labour.

The writer has used the word administration partly to call attention to the fact that the administrative aspects of factory management are likely to increase enormously in the future, and hence in certain respects to resemble more closely Civil Service administration. Hitherto the chief difference between factory management and Civil Service administration has been that in factory management the heads of it have been able to initiate and administer with an eye in the main only to the interests of their own business, and have not been hampered in the way that the Civil servant is by the necessity of constant co-operation with other departments, and by the fear of setting precedents which might embarrass the work of his department for many years to come. In the past the unique and

FACTORY ADMINISTRATION

astonishing feature of English business has been its isolation and independence of other businesses. The familiar phrase "Captain of Industry" has, if the military metaphor is pressed, been a singular misnomer. The rank and file and the non-commissioned officers have been there to receive commands, but the Generals and the military staff have been conspicuous by their absence. The captain has really been a kind of toy Field-Marshal, giving commands and moving his troops either in no co-ordination with, or in actual opposition to, the other toy armies.

The ten years prior to the war showed a gradual breaking up of this old order. It witnessed the steady rise of combinations, amalgamations, and trusts with the interlocking of businesses, and processes whereby large firms were acquiring control over the supply of their own raw material.

Further, in the field even of wages the old independence of the individual manufacturer began to disappear. He found himself more and more driven to join the Federation of other employers in the same line of business, with its common standard rates and more or less standard conditions. When contemplating giving a rise in wages he found himself faced with a code of rules or at least an etiquette, which bade him consult his federation first of all, and think of the effect which his action might have upon the welfare of other manufacturers. And on the other side he had to face the growing pressure of Trade Union organisation, with its demands for uniform standard rates and other working conditions. Further, the mere growth in size of factories rendered necessary the creation of common rules and regulations within the factory itself, which tended more and more to approximate to the common rules and regulations in other similar factories.

Since the war this movement has advanced by leaps

FACTORY ADMINISTRATION

and bounds. One can study this in its most striking form in the reports of the special committees set up by the Board of Trade to enquire into such trades as Engineering, Iron and Steel, the Electrical, the Textiles, and the like. These Committees consisted in the main of manufacturers, but through all the reports there runs the same refrain, namely, that the only hope for British manufacturers after the war was to learn to act in common, instead of acting as separate units. Agreements must be come to whereby the individual firms in any industry, instead of producing a large number of articles, must produce a smaller and more specialised range. Collective arrangements must be made for the marketing of articles, especially in the Colonies and in South America. Mr. N. J. P. Benn, himself a business man, and at the moment an official of the Ministry of Reconstruction, has written a striking if somewhat extreme picture of the possible development of British industry in a little book called *Trade as a Science*, published by Jarrold & Sons.

But the most significant feature of the new movement is the fact that it is receiving the blessing and active encouragement of the Government itself. The Ministry of Reconstruction has summoned large conferences of representative business men, and informed them that the State intends to carry on whatever rationing of raw materials may be necessary through Associations of Employers and Trade Unions wherever this is possible, and points to the Cotton Control Board as a model for this type of industrial organisation. Further, the Board of Trade, the Ministry of Reconstruction, and the Ministry of Labour have joined together in an effort to create joint organisation in each industry, thoroughly representative of associations of employers and workpeople, and have promised that these joint bodies when formed shall be recognised by the State as the only representative body for their

FACTORY ADMINISTRATION

industry, in any matter upon which the State may need advice. In the best-organised industries the Ministry of Labour is assisting in the formation of Joint Industrial Councils under the Whitley Report Scheme, while in less-organised industries the Ministry of Reconstruction is setting up Interim Industrial Reconstruction Committees to deal with problems common to a particular industry.

It seems fairly safe to prophesy that there will be a great devolution of State responsibility upon these new industrial organisations, and that in many matters the organised industries will take over much of the work which in the past has been done either by the State or by Local Authorities. Before the war, when the State wished to deal with unemployment it turned either to the Employment Department of the Board of Trade or to the Distress Committees of Local Authorities. In the future each industry will be asked to frame its own scheme for dealing with its own particular problem of unemployment, including provisions for regularising production and dealing with seasonal fluctuations.

One may picture that in the future each industry will tend more and more to have its own corporate standards and common rules, and to be increasingly responsible for its own regulation of wages, hours, apprenticeship, and the like.

In addition to the National Councils, there is gradually being built up a carefully organised system of District Councils and Works Committees. Many important problems will be dealt with in the first instance by Joint Works Committees, in which the workpeople will acquire a training in responsible self-government, and will demand an ever-increasing share in the control of industry.

Last and equally important in certain industries is the future development of Trade Boards under the

FACTORY ADMINISTRATION

new Act passed in August 1918. It seems likely that the machinery of the Trade Board will be extended in the future to all badly organised Trades, especially where the standard of wages is low. Those who have had experience of the working of Trade Boards in the past will realise how much administrative work is entailed not only upon the State Department but upon the Trade Associations and the managers of individual firms.

Hence it is that in the future the administration of business will become increasingly important. The success of business will depend more and more upon the ability of the Directors and Managers to learn to work in co-operation with the five classes of persons mentioned above, but especially with their fellow-Directors and Managers in other factories in the same industry, and with their own workpeople and with the Trade Unionists. Before important decisions can be made the Managers of a business will have to secure the assent not only of the Directors but of the Trade Unions, and the faculty of co-operation will become nearly as important as that of initiative. Further, there will be an enormous increase in the administrative side of business, especially in the working out of common rules and standards for an industry, and in the application of these common rules to individual cases. A striking instance of this movement can be seen in the change in the personnel of the secretariat of Employers' Associations. In the past the secretary of an Employers' Association was often a solicitor who was secretary of perhaps half-a-dozen other Associations in addition to carrying on his own business. In new appointments experts in the trade are being sought, and the salaries are steadily rising as well as the standards of qualification.

Looking ahead, it is clear that the administrative side of Factory Management must inevitably increase

FACTORY ADMINISTRATION

in the future, and that new responsibilities will be thrown upon the heads of factories. Already in large firms the tendency can be seen to create one or more Works Managers to deal with the labour side of the business, while in the smaller firms it is becoming customary to set aside one of the directors to specialise upon these matters. A far larger amount of time will have to be set aside in the future by the *management* for attendance at Works Committees, at District Councils, at National Councils, and at meetings of Employers' Associations, and a great deal of responsible work will be thrown upon those who attend such meetings. The demand for factory administrators must inevitably increase, and hence it is that the problem of the supply of, and the right training for, such persons becomes an immediate and urgent problem, which will be dealt with in the second part of the paper.

PART II

THE CHARACTER OF THE TRAINING

The question of any specialised form of training for Factory Administration is one of comparatively recent origin.

Educationists in the past held the theory that the best training for business as for the Civil Service was any kind of training that developed general intelligence. The majority of business people secretly held, even if they did not openly express the view, that the less education outside the business itself which the youth had the better, and even parents who could well have afforded to do otherwise often sent their sons into the business at the age of sixteen or seventeen. Speaking generally, the captains of industry of the

FACTORY ADMINISTRATION

past have been men who owed little to education, and whose education has generally terminated at sixteen or even fourteen, and indeed for the successful man of business in the past the qualities needed were just those over which education has the least influence. In the individualistic business of the past the qualities needed were either the moral quality of perseverance or the power of making decisions rapidly combined with a kind of instinct for making the right decision. There were, of course, some businesses where scientific knowledge was indispensable, but even in these cases the heads of a business often owed their success, not to their own scientific knowledge, but to their capacity for choosing the right experts. The old individualistic business was not and in most cases did not need to be, and often could not be run on scientific lines, nor did it involve more than a minimum of administrative capacity.

As far as the technical and scientific side of business was concerned it became clear many years ago that a specialised training was needed for this. Just as the medical profession insisted that a man who was to become a doctor must spend several years in attaining the necessary scientific knowledge, so it became clear that for such subjects as metallurgy, electricity and chemistry a long and severe training was necessary. Despite much criticism and some unfair disparagement it remains broadly true that the training given in these applied sciences in England, both at Universities and at schools of technology, has been of a very high order.

Of recent years, too, there has been a considerable development in commercial training, and a number of Universities now have well-equipped Faculties of Commerce. Speaking broadly, however, it may be said that the primary object of these commercial courses has been to train men who intended to be merchants rather

FACTORY ADMINISTRATION

than heads of factories. If we look at the syllabuses of these courses we shall find that a considerable amount of time and attention is devoted to such subjects as foreign languages, and accounting, and other subjects which are not as a rule needed by those men who have to administer large factories.

Hitherto there has been little done by Universities to train the man who was intended at the end of his career to look after the administrative labour side of a factory, whether as a Works Manager or as a Director of business. Still less has been done for the training of people for the more purely administrative side of business in the sense outlined in the first part of this paper.

Let us start by examining what is the kind of training needed for such a career, remembering all the time that training cannot create exceptional ability, but can only improve and develop natural gifts which are there already. Just as the training of a teacher cannot by itself produce the ideal types of teacher, so the training for business administration cannot by itself produce the ideal administrator. Training will always have the greatest effect upon the more or less average man, who has some capacity for his subjects, but who can by training learn how to use this capacity to its fullest effect.

From experience already gained it may be said that there are certain branches of knowledge or subjects which are more especially useful for the business administrator. These subjects may be divided into three main headings, namely :

- (1) Industrial History.
- (2) Economics.
- (3) Ethics.

Of these subjects History is necessary to give the background required, Economics is necessary to under-

FACTORY ADMINISTRATION

stand the actual scientific working of modern business, and Ethics is necessary in order to find out the relation of business to human well-being.

With regard to History the indispensable minimum is a knowledge of industrial history since the Industrial Revolution, and should include if possible some acquaintance with the industrial history of foreign countries as well as that of England. The differences between the evolutionist and the revolutionist can often be traced to the fact that the latter regards industrial life as having commenced in his own lifetime, while the evolutionist regards it as linked up with the past, and as having had an evolution of its own.

Economics can be divided into the science of Economics and Applied Economics. The science of Economics is needed to understand those general principles which lie behind the business structure, and although many mistakes have been made by economists in the past in their insistence upon rigid laws, far more mistakes have been due to the misinterpretation of these writings by business people who have never troubled to study them, but have selected small undigested fragments of the teaching, and twisted them to suit their own particular desires.

Perhaps the largest part of the training of the business administrator comes under the subject which we have described as Applied Economics, though but for our desire to avoid a confusion of terms it might have been called Factory Administration. Under this head we would include a careful study of Trade Unionism, including some practical acquaintance with the outlook and ideals of modern Trade Unionists. It would include, too, a careful study of modern Socialism, both of the theory of its teachers and the application given to it by men of action. As a part of it would be included such modern developments as Municipal Trading and the State activities of the

FACTORY ADMINISTRATION

Post Office, etc. It would include also a careful study of the various methods of remuneration, such as the premium bonus system and profit-sharing, together with a study of the attitude of organised labour towards such methods of remuneration. It would include, further, a study of such modern movements as Arbitration, and the working of Conciliation Boards, and a careful study of the various forms of Employers' Associations both in this country and abroad. To this should be added a study of the recent movement in the direction of Joint Industrial Councils, of District Councils, and of Works Committees, upon the last of which subjects, especially in relation to the shop steward movement, a great deal of valuable information could be got from a report recently published by the Ministry of Labour upon the operations of existing Works Committees.

The last and most important group of subjects falling under this heading are those included under the general name of Welfare. Much valuable information has been recently collected, especially by the Ministry of Munitions, upon the relation of fatigue to output, and every business administrator should be in possession of the scientific knowledge upon this subject, lying as it does at the roots of the whole question of the right length of the working day. The question of factory discipline, of appointments and dismissals also needs careful study, especially in view of recent developments such as those in the coal-mining industry. Much of the success of business in the future depends upon the right selection of young persons to enter the factory, and in this connection the future business administrator should acquire some actual experience in the working of Juvenile Advisory Committees and Juvenile Employment Exchanges. He should also study the theory that underlies the working of Adult Employment Exchanges as well as

FACTORY ADMINISTRATION

its actual practice, as also the working of unemployment insurance, with a careful study of the whole question of unemployment and of seasonal fluctuations.

He should also study the question of the education of young persons at the factory. The new Education Act will mean that all factory workers will spend some eight hours a week at school between the ages of fourteen and sixteen, and before long up to eighteen, and the right handling of this problem will become an integral part of Factory Administration. The question as to whether special works' schools are preferable to the young people in the factory attending a compulsory continuation school outside the works is one that will require serious attention, and can only be settled in the light of actual experience.

The question of scientific management in the sense of the management, not only of the productive machinery of the factory, but of the human beings who produce, is one which has excited great attention in recent years in America, and will be of great importance in England in the future. There is already in existence a mass of valuable literature upon this subject, and many mistakes would be avoided if the factory administrator had studied this subject before he was given responsibility over the welfare of workers, especially in view of the fact that the whole question of scientific management is likely to become a constant subject of discussion in Joint Works Committees.

Among other subjects which can only be briefly mentioned are the appointment of special welfare supervisors, the question of canteens, the special arrangements to be made for women workers, the general health conditions of the factory, and in some cases the provision of housing by the factory owners, the administration of the National Health Insurance Act, and the question of workmen's compensation and

FACTORY ADMINISTRATION

of pensions for workers grown old in the service of the firm.

To the present the third and last group of subjects which we have classed under the general head of Ethics is the most important of all. Some of it has been already covered under the second heading, but the more fundamental parts of it must be studied as a special subject. In its broadest sense it means a study of the relation of wealth and material things to man's spiritual nature or the question of well-being as contrasted with wealth, and a study of the spiritual aims and ideals of business. It would involve a study of the claim put forward so widely at the present time that the fundamental aim of business is service to the community in supplying those material goods which are necessary for the spiritual life of the community. It would involve, too, an enquiry into the distinction sometimes drawn between necessary expenditure and luxurious expenditure, and with the relationship of luxury to spiritual well-being. It involves an enquiry into the spiritual ideals put forward in modern times on behalf of labour and into the part played by leisure and by education in this spiritual ideal. It would involve a consideration of the question as to whether a business career can be regarded as a vocation in the spiritual sense, and what changes are needed in business structure to enable the sense of vocation to have free play. If by philosophy we mean a persistent and obstinate attempt to understand the meaning of things, then this last subject of study is a branch of philosophy, and if by religion we mean an enquiry into the spiritual value of life, then it may be truly called a branch of religion.

And in this sense the present writer agrees with those who hold that the study of economics, apart from philosophy, is fraught with danger, and that there can be no real study of the production of wealth

FACTORY ADMINISTRATION

without a study of what are the truly valuable things in life.

We have attempted in very brief space to outline the subjects necessary for the Factory Administrator, but it may be urged that we have covered far too wide a field for the average man. We agree that a complete study of these subjects would require a lifetime, but the value of such an introduction is that it would enable the future Factory Administrator in after-life to know what are the things to which he should attend, and would give him that general background which is essential for the attainment of future knowledge. Experience has shown that students who have had this preliminary kind of training learn how to keep abreast of their subjects in future life, and know how to keep in touch with and make the fullest use of the blue books, and the other literature on the subjects which is so often neglected by the ordinary business man.

We wish to lay emphasis upon the fact that a large part of his training should be given not through books and lectures but through actual visits of observation and through practice. The student should visit factories, should work for a short period in a Juvenile Employment Exchange, and, above all, should, while he is still a student, be brought into personal touch with thoughtful Trade Unionists. To attend, for instance, a good tutorial class as run under the auspices of the Workers' Educational Association would give him an invaluable insight into the outlook of organised labour, and of its aims and ideals.

We next turn to the question of the period of life at which this education should best be given. Obviously it could not be given at school, for the experience of all teachers goes to show that the mind is not yet sufficiently matured to enable the youth to derive real advantage from the study of these subjects.

FACTORY ADMINISTRATION

It should obviously be taught to adults, and the right place for it is, or at least should be, the University.

For the full course outlined above the student would require, if possible, at least three years, but this brings us up against a serious difficulty. The large majority of Works Managers have had in the past to commence to earn their livelihood at the age of 18 or 19, and this will probably continue to be the case in the future for at least a long time to come. Secondly, for a large number of Works Managers and for many Directors a considerable amount of technical and scientific knowledge is indispensable, and they must often spend at least three years upon such scientific subjects as Chemistry, Electricity, or the like.

For both these classes of persons a year's course seems the maximum possible, and any workable scheme must be framed upon this assumption. It must be remembered, too, that recent experience, especially in connection with the social study courses at Universities (see *Report upon Social Study and Training at Universities*, published by P. S. King & Sons, 6d.), has shown that more can be learnt in a year than many people have imagined. Especially is this true of people who have either had a previous University training or who come to such subjects as these after a training in the practical school of life. In the case of scientific expert, such as, for instance, the tramway manager, who will also be called upon to direct a large number of work-people, if he has already in his University scientific course learnt how to study, he will be able to acquire knowledge far more quickly than the ordinary student, who goes fresh from school to the University.

The case of the Works Manager who cannot afford to go to a University but who is gradually promoted as a result of work in the firm requires special consideration. Many heads of large businesses know by the time that a young man in the firm reaches the age of

FACTORY ADMINISTRATION

22 or 23, that he is the kind of person who would in the future make a suitable Works Manager, and the ideal line of action would be for the firm to send such a man, either wholly or partly at their own expense, to a University for a year's course. Coming as he would with a mass of practical experience, and with a mature mind, he would as a rule make an excellent student, and could in a year learn, if not as much as could be learnt at a full course, quite enough to be of invaluable assistance in his future career.

What we require at the Universities are two different courses of training, one lasting three years and the other one.

The three years' course would be especially valuable for sons of business men who were intending to enter their fathers' businesses or for those who had some definite opening ready which would in the normal course of events lead to their becoming Directors, especially in work where little or no technical knowledge was needed. It might be urged that for such people it would be better for them to go first into business for a few years, and then go on to a University, when they had gained some practical experience of the conduct of the business, and knew what it was that they wanted to learn. Such a course has been strongly advocated in certain quarters partly on the ground that a young man ought to become accustomed to the routine of the factory at an early age, and acquire habits of grinding away at dull work. Without wishing to be dogmatic upon the subject, the writer is of opinion that, apart from a few exceptional cases, a manufacturer who wishes his son to follow him in the business would be well advised to send his son straight from school to the University. One cannot deny that some young men do acquire idle habits at Universities, but in the writer's experience this is generally due to the fact that they have not been interested in the

FACTORY ADMINISTRATION

subjects which they have been told to study and have regarded them as having no bearing upon their future life's work. The experience already gained tends to prove that such a course as that outlined above does attract and interest a young man fresh from school, provided that, and this is all-important, he genuinely wishes to enter business, and is not being compelled to enter it merely by the pressure of opinion among his elders. The greatest enemy of idleness is interest, and hence the importance of giving the average student something that, while giving him a good mental discipline, also interests him as having a practical bearing upon his future life.

To the present writer the strongest argument in favour of going straight from school to the University, wherever possible, lies in the psychological nature of the years between 18 and 22. This is the period in life when the mind is most receptive to new ideas and most anxious to get at the causes of things. Quite apart from the value of lectures and the more formal teaching, the young man gains enormously by being thrown among a body of young men all after their own fashion seekers after truth and all helping to educate each other from the interplay of ideas. Further, the young man at the University, by being brought into contact with other young men, often of exceptional ability, learns to form a truer estimate of his own ability, and avoid that cocksureness and contempt for the ideas of the other people which has so often been a handicap to business men in the past and will undoubtedly be a still greater handicap in the future, when success in business will depend more and more upon the power of carrying with one not only one's fellow employers, but also the leaders of the Trade Union, and one's own work-people.

What is required is two kinds of courses at Univer-

FACTORY ADMINISTRATION

sities, first of all a three years' or four years' course in Factory Administration for those who are in a position to go straight to the University from school, and in the second place a special one year's course to be taken by scientific and technical experts at the end of their scientific and technical course,¹ and also by those men who have not been able to go straight to the University, but who will be liberated by their firm to spend one year at a University, preferably about the age of 22 or 23.

The question may be raised as to how far such courses are already in existence at Universities, and how far they will have to be specially devised. As far as the three years' course is concerned there are already in the writer's experience certain courses which contain at least a part of the curriculum mentioned above, such as, for instance, the Economic Tripos at Cambridge, and the courses at Manchester² and other Universities and the London School of Economics. Unfortunately both at Cambridge and at the London School of Economics, as indeed in other more strictly Commercial courses, the study of Ethics has been entirely omitted. Further, the education in such courses at present consists almost entirely of lectures and reading, and the practical work and visits of observation have been in the main neglected.

With regard to the one-year courses they do not as far as the writer knows exist at all, and the nearest

¹ Such a course might, in the case of the technical student, be spread over the whole of his technical course instead of being put into a one year's course at the end.

² Since the date on which the Lecture was given, the Department of Industrial Administration has been founded in the Manchester Municipal College of Technology. It provides courses of instruction which conform to some extent to the suggestions here put forward. For instance, the value of practical work and of visits of observation is thoroughly recognised, whilst arrangements are contemplated whereby instruction in Industrial Administration will be spread over the whole of the course taken by technical students, instead of being taken as a special course at the end of the curriculum. Courses are provided also for those already engaged in industry, whose time is limited, and whose opportunities for such study are few.—
THE EDITOR.

FACTORY ADMINISTRATION

parallel is to be found in those social study courses to which attention has already been called, and which are described in the report mentioned on page 179. The reason why such courses do not exist is in the main due to the fact that hitherto there has been little or no demand for them. What is needed is for a group of business men to approach a given University, or group of Universities, and to put such a request before them.

The supply of education depends to a considerable extent upon the demand that exists for it, and it would be of the greatest assistance to the Universities, and would receive a most ready welcome from them, if a group of business men were to ask for a conference upon the subject. Further, it must be remembered that Factory Administration is a comparatively new thing, and the demand for trained Factory Administrators in the sense used in this paper is only beginning to arise. So long as success in business depended upon powers of initiative, and a kind of natural knack, it could not be expected that business men would demand this more scientific kind of training. The leaders had succeeded without it, and they were conscious that they would certainly not have done better with such education, and might possibly have done worse. The experience of the twentieth century, and especially of the recent war, has brought into prominence three new factors. These are, in the first place, the necessity for employers to work in closer co-operation with other employers in the same industry ; in the second place, the ever-growing demand of labour to have a share in the conduct of the business ; and in the third place, and perhaps most important of all, the growth of the feeling among business men themselves that in future ethical considerations will have to play a larger part in business than they have done in the past. Just as the growth of medical knowledge and the emergence of

FACTORY ADMINISTRATION

new ideals in the art of healing brought about a higher standard of training for doctors, so the growth of these new ideals in business must inevitably bring about a demand for an improvement in the training of Factory Administrators.

INDUSTRIAL FATIGUE

Industrial Fatigue

By A. F. STANLEY KENT, M.A., D.Sc.

A LECTURE GIVEN ON APRIL 26, 1919.

I HAVE been asked to speak to-day of Industrial Fatigue, and I do this more willingly because in my opinion the hope of industry in the future lies in a right understanding of the *nature*, the *causes*, the *results*, and the *prevention* of industrial fatigue.

Were I to ask what is understood by fatigue, it is possible that you would not find it easy to frame a satisfactory definition, though almost every one knows from personal experience what the sensations of fatigue are like. These sensations are akin to weariness, are associated with a disinclination for further exertion, and in the majority of instances follow, and to some extent are caused by, the performance of work. That they are no indication of any *impossibility* of further work being carried out is shown by the fact that even heavily fatigued individuals become active as soon as a sufficiently powerful stimulus is applied.

For our present purpose we need to know more of the nature of fatigue than can be gleaned from mere sensations, and the physiologist has investigated the subject pretty thoroughly, and is able to explain its nature. To-day I will translate his statements into commonplace language, and endeavour to get along without any technical terms.

To this end we will compare the highly complex human machine with the more familiar steam or petrol engine. Both require fuel, both produce, as a result of their action, certain waste matters which must be got rid of. From the funnel of a steam engine the carbonic acid gas escapes along with smoke and steam; from the petrol engine it escapes by the exhaust. In the human machine it escapes from the mouth and nose

INDUSTRIAL FATIGUE

in respiration. The incombustible portion of the fuel of the steam engine, the road dust drawn in and the deposited carbon in the car, are treated as waste matter, and must be got rid of by appropriate means. If this be not arranged for the fire burns low, the engine works badly, and the results are unsatisfactory. And so with the human motor. The indigestible portions of the food are waste matter and must be eliminated. Their continued presence leads to inefficiency.

You will recollect that the fuels used by different types of engines differ widely. For the steam engine coal, or wood, or oil. For the internal-combustion engine petrol, or benzol, or paraffin. And to attempt to use a fuel, however good, in a machine intended for another will lead to trouble. It is so with the food of animals. In some the fire box, or digestive system, is made to deal with flesh, a highly concentrated diet. In others vegetable material is the appropriate food and a longer intestine gives a longer time for the nutriment to be extracted from a less highly concentrated material.

Some of you may remember to have seen in France, and other places, railway engines less efficient than those we are accustomed to at home, expressing their abhorrence of unsuitable diet (in the form of soft and caking coal) by vomiting clouds of offensive smoke. In a similar manner an animal designed to make use of one kind of food becomes less efficient when compelled to use another, and the proper selection of the food of the working classes is of the utmost consequence in any attempt to reach efficiency.

It is possible, and perhaps profitable, to push the comparison between the organic and inorganic motor even further. For just as in a petrol engine brass and steel are gradually worn off the bearings, gears, and other moving parts as minute particles, which are

INDUSTRIAL FATIGUE

removed by the lubricating oil and strained off before the oil is allowed to flow again, so in the body a gradual disintegration of the muscles takes place, and the products reach the blood and must be removed by the kidneys. If in the car dirty oil is used wear is increased, and if in the body the kidneys do not perform their functions the efficiency of the machine is lessened.

Briefly, then, it may be said that fatigue depends partly upon the using up of fuel—a conception so familiar that it requires no further emphasis—and partly upon the accumulation of waste material. This latter factor is not unimportant, even when the muscles alone are considered; an isolated muscle which has contracted until to all appearance completely tired may be refreshed, and induced to work again by merely washing out its blood-vessels with a solution of common salt. Evidently the salt can afford no fresh supply of energy. It merely removes waste products, and the muscle acts again. Fatigue in this instance was largely a matter of a clogging of the mechanism.

But it is not only the muscles we have to consider. They are under the control of nerves and the central nervous system—the brain and spinal cord. And the nervous system is a far more delicate structure than the muscles, and likely sooner to be damaged by the presence of waste material. That the tissues are not really exhausted, even in extreme grades of fatigue, has already been shown; since further exertion is possible in response to a sufficient stimulus.

So much, then, for the *nature* of fatigue. What of its *causes*?

Evidently it will be caused by any circumstance that leads to a using-up of the energy-producing material in the body, and the more rapidly this using-up goes on the more rapidly will fatigue supervene.

INDUSTRIAL FATIGUE

It may be deferred by supplying abundance of suitable food, so long as opportunities for proper digestion are afforded, and it may be put off for long periods by the introduction of rest periods, which allow of material, present in the body as partly prepared energy producers, being made fit for immediate use in the furnace of the cell.

Some of you will remember how when on a climbing expedition the guides insist on frequent pauses, not altogether for rest, but also for refreshment. The two together have a wonderful effect in postponing the incidence of fatigue.

Fatigue will also be caused by anything that favours an accumulation of waste products in the body, whether these waste products be derived from the activity of the mechanism or have been produced in other ways. Some writers have gone so far as to describe specific "*fatigue-poisons*," the presence of which leads to a feeling of weariness, and certain it is that experiments have been made in which the blood of a fatigued animal, introduced into the veins of another, has given rise to all the symptoms of fatigue.

Unfortunately, there is another source of waste material in the body whose presence may give rise to fatigue. Food, however good, and however suitable, requires to be digested before it is fit for absorption and use in the body. And digestion is a process of some complexity and of considerable duration. It is easily upset and started along wrong lines, and its results may be, instead of first-class nutriment, actual poison. Most of the people who are "*always tired*" are suffering from intestinal poisoning, the results of indigestion being similar in some ways to those of prolonged work.

This fact of the influence of indigestion upon efficiency is not yet by any means as widely appreciated as it ought to be, since it offers a possible

INDUSTRIAL FATIGUE

explanation of many instances of undue fatigue. For instance, we all know how greatly the mental condition affects digestion. "A chattered meal is half digested." A hurried lunch, snatched between engagements, is altogether unsatisfactory. Pain and grief and worry—more particularly worry—may lead to acute and lasting indigestion, with consequent fatigue and loss of vigour. Unfriendly supervisors have been quoted as a cause of serious loss of output. Dazzling lights, improperly arranged, by straining and irritating the workers' eyes, may lead to a mental condition incompatible with "*Eupepsia*"—so necessary to "fitness."

Noise, though at present the fact is scarcely recognised, often leads to fatigue, even though, in many cases, long use has made the workers oblivious of its presence.

Such unconsciousness does not protect from injury. Even under an anæsthetic an organism may be "shocked," and death has occurred as the result of too heroic dental treatment, even where all feeling was abolished.

Bad ventilation is a fruitful cause of fatigue, not only through the often-quoted lack of freshness of a stagnant atmosphere, but also through the lack of stimulation of the skin, and the cooling properties of an atmosphere in movement.

Thus eyes and ears, sight and hearing, may be concerned in determining efficiency. What of taste and smell, and feeling?

The last has already been referred to under ventilation: the stimulation of the skin through moving currents of air has a beneficial action.

Taste and smell may be taken together, since very many of the "tastes" of man are in reality "smells," and both together go far to determine how far a meal shall be appreciated and enjoyed. Hence the use of

INDUSTRIAL FATIGUE

condiments and spices, which aid digestion through their power of increasing the secretion of the digestive juices. Sight also comes in here, since in a hungry animal the mere sight of food is sufficient to cause a copious flow of gastric juice. • •

The *results* of industrial fatigue are beginning to be appreciated to-day as never before in the history of industry. In two words, it *limits output*. It leads to inefficiency in the worker. If long continued, permanent incapacity may be its ultimate result. Evidently, then, it deserves the most careful consideration, since only by increased production can we hope to pay the enhanced wages now paid to labour.

There are several ways in which this limitation of output is brought about through the influence of fatigue. In the first place, the actual rate of working is largely influenced by the state of the worker with regard to fatigue. A fatigued person works less rapidly than one who is fresh, and the rate of working appears to get slower and slower as the process of exhaustion proceeds. This is evident even when the conditions of labour are favourable and the length of the working day is not excessive. With any lengthening of the hours, when the worker is already fully loaded, a rapid diminution in efficiency takes place, the rate of working for the whole day is seriously affected and often leads to a diminution of total output, whilst the output during the extra hours is small and consequently costly, even at ordinary rates, and when examined in the light of the extra wages paid is seen to be extravagant. Contrary to what might be expected, this unsatisfactory output is not confined to the period at the end of the day usually referred to as "overtime." It is found also in the first hours of the working day, especially as, in many cases, an early start means an unsatisfactory breakfast. It may perhaps be said that in such a case the result cannot

INDUSTRIAL FATIGUE

fairly be attributed to fatigue, but since the disinclination to get up early and take an adequate breakfast is largely due to excessive strain, the case is not unfairly stated. Moreover, in actual investigations that have been carried out to clear up the point, it has been proved that by cancelling the working period of the early morning, total output has been increased and the general condition has been improved.

In fact, it is only necessary to examine the conditions of fatigue, of output, and of payment, which exist in the hours usually described as overtime in any large concern to realise how mistaken has been the tendency in the past to meet a demand for greater output by an attempt to lengthen working hours.

This mistake was made very generally at the beginning of the war. It involved the nation in an enormous expense which was not only entirely unnecessary, but was actually incurred through a procedure which lessened, instead of increasing, total output.

It is not even yet realised to what an extent output may suffer through an unwise lengthening of working hours. It is not only that the rate of working of the men and women in the factory is diminished; it is that a considerable proportion of the working staff absent themselves from the mill in consequence and go on the sick list.

I shall show you examples of this, and meanwhile it is not too much to say that in many instances the loss of time through sickness induced by the fatigue engendered is more than sufficient to neutralise any advantage hoped for from an increase of hours beyond a reasonable limit.

And this brings us to a question of extreme difficulty. *What* is to be regarded as a reasonable limit of hours of labour? What should be the length of the working day? The answer to this question depends

INDUSTRIAL FATIGUE

almost entirely on conditions. It is altogether impossible to give a general answer to fit all cases. Often it is necessary to carry out a careful examination of existing conditions before a lengthening or a shortening of existing hours can be advised. And the introduction and arrangement of rest pauses will have a great effect.

Yet it may be said with certainty that the best result, in the sense of greatest output with least fatigue, can only be obtained by a careful adjustment of hours of work to the conditions of the operation concerned, and that the real interests of capital and labour, which, indeed, in this respect are almost identical, should be secured through such an arrangement based on scientific principles.

There is one other matter of great interest that should be referred to in connection with industrial fatigue. It is the incidence of accidents in industrial occupations. Whether fatigue does, or does not, directly control the incidence of accidents in such a manner that the number of accidents is increased by an increase of fatigue, and lessened by its diminution, it is very difficult to determine from the data at present available, and the difficulty is increased because there are other influences, to some extent independent of fatigue, that appear to influence the result. Were I asked to hazard an opinion, I should say that the experience of the last seven years leads me to believe that amongst the causes of industrial accidents, industrial fatigue will be found to occupy a not unimportant place.

With regard to the limitation of industrial fatigue, it is not necessary to say much. The general lines upon which this must be attempted are sufficiently indicated in what has already been said with regard to its causation. A length of working day appropriate to the particular occupation concerned is of the first

INDUSTRIAL FATIGUE

importance, and with this must be considered the number and duration of rest periods. It should always be remembered that fatigue, and recovery from fatigue, are parallel processes, that they accompany each other, and that by comparatively small adjustments the one or the other may be allowed to prevail. A rest period of short duration may be enough to check the development of fatigue, and to encourage recovery, at a given point in a work period ; later in the same period it may be found of little use. So complex is the mode of action of the human machine !

INDEX

- Advisory Assistants, Apprentice Master (*see* Industrial Advisory Assistants, *also* Educationist)
- Apprenticeship, age of wage-earning under alternative training schemes, 66-70
 - chart of alternative training schemes, 73
 - Elizabethan system, 60
 - Engineer, 67-68, 71
 - feeling of security essential, 54
 - Guilds and, 60
 - influence of original system, 63
 - legal agreement advisable, 54
 - origin and development, 59-64
 - part-time education, 67, 68
 - popular prejudice to, 54
 - position of respective parties in modern system, 64
 - premiums and, 62-63, 72
 - Pupilage, 70-72
 - records important, 65, 71
 - reform needed, 142
 - revival, 64-65
 - Special Apprenticeships, 65, 67
 - training facilities, 65, 67-71
 - training schemes analysed, 66-70
 - wages and, 55, 66, 72
- Atmospheric conditions, 101-132, *passim*
 - chemical impurity theory erroneous, 102, (Haldane) 103
 - cooling methods, artificial and natural, 110-113
 - cooling power, indoor and out, 109-111, 112-113 (*see also* Cooling Power)
 - Du Bois, formula, 115
 - experiments (Flack, Ash, and Hill), 111-112
 - fallacies, 101, 102, 103
 - fatigue, 106-107, 108, 110, 112, 191
 - harmful effects of close air, 103-104
 - heat-production experiments, 115-121, 122-124
 - heat-stroke, 110, 113
 - infection, 104, 113-114, 119, 121
 - kata-thermometer, 109-132, *passim*
 - life statistics, 107
 - nasal secretion, artificial and natural, 113-114, 121
 - open-air methods, 101, 102
 - work at comparative temperatures, 112, 115-122
- Attention, differentiation illustrated, 38
 - Fleming and Pearce on (*footnote*), 38
 - industrial value, 38
 - Münsterberg on, 38
- Charts, alternating industrial schemes, 71
- Children (*see also under* Apprenticeship, Educationist, etc.)
 - apprenticeship revival, 64-65
 - change of air and occupation, 108-109
 - cost of grants for, 14
 - historical survey of place in industry, 59-64
 - hours of labour limited, 63, 81 (Percival, Owen, Oastler, Sadler, Shaftesbury)
 - housing and, 107, 108
 - malnutrition, 108
 - minimum age for labour, 63-64
 - minimum wage and, 14
 - Owen (Robert) and child labour, 63, 81

INDEX

Children (*contd.*)—

- rickets prevalent in cities through lack of vitamins, 108 (Mellanby)
- College course, best time for, 69, 178-179, 180-181
- industrial value, 68-69
- practical training with, 69-70, 178, 182
- Sandwich system, 70
- Special apprentice and, 68
- Collis (Dr.), examination of card-strippers, 94
- Compensation, Workmen's, 87
- charges in 1913, 87
- comparison of claims from various industries, 87
- diseases scheduled 1906, 82
- mining industry, highest claims, 87
- Cooling power, accidents and, 121
- clothing and, 112
- diagrams, 125-132
- efficiency and, 110, 112, 115-122
- experiments (Flack, Ash, Hill), 111, 115-121, 122-124
- infection and, 113-114, 119, 121
- kata-thermometer, 109-132, *passim*
- nervous energy and, 110, 191
- tropical climates and, 111, 119
- Co-operation, early experiments in, 59-62
- Cost of living, apprenticeship and, 66, 72
- at 1914 prices, 6-10
- influence of agriculture, 11
- level of wages set by, 9-10
- for men, 6, 7
- wages and, 9-10
- for women, 7-9
- Gosts (*see under* Factories)

- Dearden (F. W.) and Knecht (Professor), *Injurious Effect of Fast Anilin Dyeing Processes*, 88
- Délépine (Professor), anthrax investigations, 98
- Disease, Occupational, 81-98, *passim*
- accidents distinguished from, 82, 83
- anthrax amongst woollen workers, 97-98 (Eurich, Duckering, Délépine)
- asthma amongst card-strippers (Collis), 94
- cataract amongst glass-workers, 95
- classified, 82-83
- compensation for, 82

Disease (*contd.*)—

- consumption amongst light hand-workers, 106-107
- cramp amongst writers and telegraphists, 95
- deafness amongst boiler-makers, 90
- employer's obligations against, 86
- injection and anthrax, 98
- jaundice (*see* Jaundice)
- limited success of preventative measures, 85
- notification, 82, 84, 90
- nystagmus amongst miners, 94
- poisoning, 81-82, 83-86 (*see also* Poisoning, Absorption, and Poisoning, Industrial)
- prevention schemes, 81, 86, 92-94, 96, 97-98, 121
- statistics, 84, 85, 107
- strain, 83, 95, 97
- susceptibility varies in individual, 84
- Watson on, 83
- working conditions causing, 83, 106
- working conditions preventing, 114
- Du Bois, formula, 115
- Education, continuity of supervision essential, 54
- management and, 20-21, 51, 57-58, 176
- 1918 Act, 58, 67
- part-time, 67, 68, 176
- threefold qualities essential in industry, 51
- Educationist (*see also* Industrial Advisory Assistants)
- apprenticeship most successful sphere for, 54, 58
- focus on abnormal qualities of workers, 71
- functions, 52, 53, 55, 56, 71-72
- personality essential, 56
- psychological investigation (Myers), 57-58
- qualities required, 52, 55, 56
- responsible position, 72
- schoolmasters' co-operation essential, 72
- varied occupation, 56
- value to management, 53, 57
- value to workers, 53
- Efficiency, atmospheric conditions, 101, 106-107, 109, 111-112, 115-119, 120-121 (Vernon)
- change, 108-109
- cool surroundings, 112

INDEX

Efficiency (*contd.*)—

- diet, 106, 107, 108, 188-189, 190-191
- economic conditions, 39, 82
- heat-production, 115-121
- housing, 107-108
- rest, 106, 107, 190, 192-195 •
- wages, 10
- Elderton, *Primer of Statistics* (*foot-note*), 34
- Employer, association secretary should be trade expert, 170
- Education Act, 1918, and, 58
- education a function of management, 20-21; 51, 58
- improved efficiency of, 11, 12, 142, 170, 171
- indifference to Industrial Union, 137
- paternal attitude under Guilds, 59, 60
- relationship to workers, 1, 20-21, 59-64, 72, 137 (*see also* Industrial Councils, Factory Administration, etc.)
- safety of worker depends on, 86
- unemployment and, 17
- wage increase and profits of, 10, 11, 144, 149, 155
- welfare work, 19-21, 175, 176
- Engineer Apprenticeship, 67-68, 71 (*see also under* Apprenticeship, College Course, etc.)
- Factories (*see also under* Industry and Workers)
 - administrative inefficiency in, 11, 141
 - conditions of work in, 4, 18-21, 39 (*see also under* Workers, Improvement of Working Conditions)
 - costs, analysis and comparison of, 11, 12
 - costs, analysis and comparison of international, 148
 - costs, overhauling of, 11, 12, 141, 142, 145, 148
 - Factory administration (*cf. also* Educationist)
 - comparison with Civil Service, 165-167
 - definition of terms, 163-165
 - District Councils and Works Committees, 169
 - general inefficiency, 11, 141
 - importance, 170-171, 183
 - Industrial Councils (*q.v.*)

Factory administration (*contd.*)—

- training, best period of life for, 178-179, 180-181
- financial assistance desirable in certain cases, 180
- formerly unspecialised, 172, 183
- length of course, 179-180, 181-182
- new factors in industry demand improvement, 183
- practical training comparatively neglected, 182 •
- practice besides theory, 178, 182
- present facilities, 182
- University best place for, 179
- Factory legislation, 63-64, 81-82
- Elementary Education Act, 1876,
- Juvenile Employment Act, 1819,
- minimum age and maximum day, 63-64
- Workmen's Compensation Act, 82, 87
- Fatigue, 15, 27, 82, 106-107, 187-195, *passim*
- accidents and, 194
- atmospheric environment, 106-107, 108, 110, 112, 119-122
- boredom compared with, 41
- change, 108, 109
- consumption, 106
- investigations, (Florence, Rivers) 40, (Rivers) 41, (Kent) 95-97, 175, 187-195
- nature of, 187-189
- nervous exhaustion, 106-107, 108, 110, 189, 191
- nutrition, 106-107, 187-189, 190-191
- output and, 15, 27, 120, 192-195
- overtime, 192-193
- rest pauses, 41, (Taylor McKillop) 42-43, 190, 194, 195
- settling down, 41
- ventilation and, 110, 191
- warming-up, 41-42
- weariness compared with, 40, 187
- Filson Young, *New Leaves*, 46
- Flack (Col. Martin), Ash (Miss D. Hargood), Hill (Dr. Leonard), cooling power experiments, 111
- Fleming and Pearce, *Principles of Apprentice Training*, 38
- Florence (P. S.), *Use of Factory Statistics in Investigation of Industrial Fatigue*, 40
- Food, economically chosen, 6, 106, 108, 188
- importance of good canteen, 19

INDEX

- Food (*contd.*)—
infection through, 104
minimum cost, 6, 7
vitamines essential, 106, 108
(Mellanby)
- Gilbreth, on methods of work, 39, 46
Motion Study, Fatigue Study, Applied Motion Study, 45
- Guilds, Apprentices under, 60
history, 59-63
inspection by Searchers, 60
monopolist companies by Royal Charter, 59
monopolist policy caused downfall, 62
paralysing effect of Great War, 61
social privileges of members, 61
young persons and, 60-61
- Haldane (Dr. John), on concentration of carbonic acid in the lungs, 103
- Health, Public (*see also* Disease, Occupational)
accident prevention, 81, 82
child labour and shorter hours, 81
dangerous trades, 81, 82-98, *passim*
disease prevention, 81, 82, 85, 101
education and, 142
fresh air and, 101-102
leisure and relaxation required, 108
pioneers, 81
popular fallacies, 101, 102
research, 82, 84, 101-102, 142
three periods of legislative activity, 81
variety in occupation essential, 109
- Hill (Dr. Leonard), on ventilation, 93-94
cooling power experiments, 111
Report on Science of Ventilation and Open-Air Treatment, 116
- Industrial Advisory Assistants (*see also* Factory Administration)
economy and efficiency by, 11, 58-59
education and welfare work, 20-21, 51-58, 176
importance, 55-56, 71-72
psychological investigation (Myers and Taylor), 27, 57
selection and promotion of workers, 27, 29-31, 53, 56
varied occupation, 56
- Industrial Councils, a Socialist ideal, 157
- Industrial Councils (*contd.*)—
Bristol Report, 139
employers' indifference, 137
extremists retard progress, 138
founders, 135
importance of statistics, 142, 145
Industrial Appeal Court, 149
international value of National Councils, 156
members of first conference, 136
objects, 135
organisation by Charters, 151-155
organisation, valuable results of, 155-157
Pottery National Council, 138-145
questions and answers at lecture at Manchester, 58
regularisation of production and employment, 139, 140, 141, 144, 167-168, 169, 170
research and, 142, 144, 145
Rowntree's conferences, 138, 139-140
scheme, 139
settlement of disputes and strikes, 138, 144
Sheppard's scheme, 138
Socialist attitude, 137
State support desirable, 140, 141
system of National Kartels, 157
urgent need, 138, 139
Whitley Report anticipated, 138
- Industry, accidents, 81
causes of growth and development, 2
complexity of modern system, 167
dangerous trades, 81, 82-98
disease, 81, 82-98
education and, 51-77, *passim* (*see also under* Education and Educationist)
ex-soldier problem in seventeenth century, 61
Guilds, 59-60
juvenile workers, 59-64, 81
Master-craftsmen in Middle Age, 59
psychological observers and, 27 (*see also under* Industrial Advisory Assistants)
scientific research in, 12, 98, 172
selective tests in, 30-34 (*see also under* Workers, Selection of)
shorter hours in, 14, 27 (*see also under* Shorter Hours)
Trade Boards, 12-14, 139, 169-170
unemployment and limited output, 16, 17

INDEX

Industry (*contd.*)—

- University career and, 68
- women workers, 7-9, 81
- Infection, cleanliness the great preventative, 105
- direct and indirect, 104
- injection, 98, 114
- nasal secretion defence against, 114
- open-air exercise and, 114
- preventative measures, 98, 104, 105, 106, 114

- Jaundice, mortality, 89, 93
- notification, 85, 90
- occupations causing, 85, 88-93
- preventative measures, 89-90, 92-93
- Juvenile Employment (*see under* Apprenticeship, Children, Industry, Shorter hours)

- Kent (A. F. Stanley), on fatigue, 95, 96, 187-195 *passim*

- Labour-saving devices, minimise industrial poisoning, 86

- Lancet*, on reaction in R.A.F. candidates, 37

- Lead-poisoning, causes, 86
- inhalation and, 86
- labour-saving devices and, 86
- mitigation statistics, 85
- serious effects, 81, 84
- time lost from, 87
- ventilation and, 86

- Life Statistics, atmospheric and occupational, 107

- McKillop (M. and A. D.), *Efficiency Methods*, 43, 44

- Mellanby (E.), on vitamins and rickets, 108

- Mental capacities, industrial value of particular, 30, 32-33

- memory span, 35
- motor imagery, 36
- psychologically tested, 33, 34
- visual perception rate, 35

- Minimum Wage (*see* Wage, Minimum)

- Mining Industry, highest compensation claims, 87

- nystagmus prevalent, 94
- ventilation and, 121

- Moore (Dr. Benjamin), T.N.T. experiments, 90

- Motion Study, aims, 43
- cyclegraph and kinematograph, 45
- cyclegraph and stereoscopic photography, 45

Motion Study (*contd.*)—

- fatigue, 44
- lessons from, 46, (Filson Young, Gilbreth) 46-47
- output and, 44
- practical experiments, 44, (Gilbreth, McKillop) 45
- Münsterberg (Professor), *Psychology and Industrial Efficiency*, 32-33, 35, 38 (*footnote*)
- Muscio, *Lectures on Industrial Psychology*, 35, 36
- Myers (C. S.), *Present-Day Applications of Psychology*, 27, 37, 58

- National Council (Pottery), aims, 140-142, 144-145
- constitution, 142-144
- initial experiments, 137-139
- results, 145-146

- New York Commission, Ventilation tests, 112

- Owen (Robert), and child-labour, 63, 81

- Part-time education, 67, 68, 176

- Poisoning, Absorption, through skin and lungs, 87
- blood-poisoning from, 88-91
- card-stripping, 94
- Collis (Dr.), investigation, 94
- D.N.B., 88-90, 93
- jaundice, 85, 88-91, 93
- preventative measures, 92-94
- tetrachlorethane, 91-93
- T.N.T., 85, 87-90

- Poisoning, Industrial (*see also* Disease, Occupational)—

- absence of precautions causes, 83, 86
- anthrax, 97-98 (Eurich, Duckering, Délepine)
- benzene and derivatives, 88-90, 93
- by absorption, 87-91
- by inhalation, 82, 83, 86
- chronic disease, 83, 86, 91, 94
- cleanliness and, 86, 89, 90
- coal-tar and derivatives, 85, 87-90
- compensation for, 82, 87
- defined, 83
- difficulties of differential diagnosis, 84
- dust irritation, 82, 83, 86, 94
- experiments, (Dearden, Knecht) 88, (Hay, Prosser White) 88, 89, (Moore) 89-90, (Eurich, Duckering, Délepine) 98

INDEX

Poisoning, Industrial (*contd.*)—
 jaundice from, 85, 88-89, 91-93
 labour-saving devices minimise, 86
 lead-poisoning (*see* Lead-poisoning)
 medical examination, 84, 85, 86
 obligation to notify, 82, 90
 slow-onset, 85
 trades causing, 81-82, 84-94 *passim*
 Psychology, common sense, 26
 coefficient and correlation, 34
 definition, 25
 educationist and applied, 57-58
 higher wages and applied, 58
 industry and, 27, 32-34, 38, 57-58,
 82
 investigation problems, 28, 57-58
 (Myers)
 tests, (Münsterberg) 32-33, (Muscio)
 35, 36
 Pupilage, 70-72
 personal obligations, 72
 records and, 71
 Sandwich system, 71
 Reaction, differentiation of, 37
 R.A.F. and, 37 (*Lancet*)
 Records, important feature in modern
 apprenticeship, 65, 71
 methods in keeping, 71
 specimen forms, 74-77
 Rivers, *Influence of Alcohol and other
 Drugs on Fatigue*, 40, 41
 Sandwich system, practical and theo-
 retical work alternated, 71
 Shorter hours, distribution, 31, 194-
 195
 education and, 16, 58
 • fatigue, 15-27, 120, 192-195
 juvenile workers and, 63, 81
 output, 15, 27, 120, 192-195
 psychological investigation and,
 (Taylor) 26-27, (Myers) 58-59
 value, 14-16, 82
 ventilation and, 120-121
 women workers and, 81
 Smith (W. Sydney), on ventilation of
 dope-rooms, 92-93
 Special Apprenticeship, 65, 67
 college course and, 67
 State in relation to: Charter to trades,
 151, 152-155, 157
 compulsory membership of Unions,
 140, 150-151, 155
 co-ordination, 153
 devolution of control to industrial
 organisations, 157, 167, 168

State in relation to (*contd.*)—
 employment, enterprise, experi-
 ment, 141
 Government contract problems, 141
 grants for dependent children, 14
 minimum wage, 12-14
 representatives at Industrial Coun-
 cils, 142, 152-153
 supporting industrial federations,
 140
 Statistics, American Commission and,
 146-148
 anthrax amongst wool-workers, 97
 asthma amongst card-strippers, 94
 cataract amongst glass-workers, 95
 Government collection desirable,
 153
 importance to industry, 11-12, 142,
 145-146, 149
 industrial disease, 84-85
 lead-poisoning, 85
 publicity essential, 140, 146, 149,
 153, 155
 toxic jaundice, 90
 workmen's compensation, 87
 Taylor (F. W.), *Principles of Scientific
 Management*, 27, 39, 43
 Trade Boards, 12-14, 139, 169-170
 1918 Act, 170
 Trade Unions, compulsory member-
 ship essential, 140, 150-151, 155
 co-operation, 140, 141, 150, 167-
 168
 joint conferences and, 137, 139,
 143, 168-169
 National Pottery Council and, 138,
 139, 141, 142-145
 relationship to Civil Service depart-
 ments, 166, 168
 shop committees and, 140
 Socialist opposition, 137
 study essential to factory administra-
 tion, 174
 Tuberculosis, causes, 83, 102, 106-107
 Unemployment, causes, 16, 17
 employer's obligations, 17, 18
 insurance and benefit, 18
 mitigation problem, 16-18, 96, 141,
 145
 State assistance against, 141
 worker's deterioration under, 18
 worker's obligations, 17
 Ventilation, dope problems, 91-92, 92-
 93 (W. S. Smith), 93-94 (Hill)

INDEX

- Ventilation (*contd.*)—
 essential features, 92, 94
 heat-production and energy, 115-121
 infection and, 114
 lead-poisoning and, 86
 nervous system and inadequate, 110, 191
 New York Commission tests, 112
 output and, 120-121 (Vernon)
 welfare movement and, 19
 Vernon (Dr. H. M.), on ventilation and output, 120-121
- Wage Boards (*see* Trade Boards, *also* Industrial Appeal Court *under* Industrial Union)
- Wage, Minimum, agriculture and, 13
 cost of living determines, 9-10
 for family of five, 5, 6
 for man, 5
 industry's ability to pay, 10, 141, 142, 144, 169, 192
 large families under, 13-14
 proportion of men earning, 7, of women, 9
 under economic conditions, 5
- Wages, apprenticeship and, 55, 66
 education and, 58, 66-72
 higher wages and psychological investigation, 58
 low wages and inefficiency, 10
 profits, 10, 11, 144, 149, 155
 publicity, 140, 146, 149, 153, 155
 reform, 12-13, 140, 142, 144
 sources of increase, 10-12, 192
 State interference, 12-13, 140
- Watson, on occupational disease, 83
- Welfare Work (*see under* Employer, *also under* Workers, improvement of working conditions, *and* recreation and leisure)
- White (Dr. Prosser) and Hay (Dr. J.), D.N.B. experiments, 88, 89
- Whitley Councils, anticipated, 138
 executive powers, 150
 justified, 145
 movement for, 21
- Workers, dependent children, 3
 education and *esprit de corps*, 20-21
 improvement of working conditions, 4, 18-20, 39-43, 57, 58-59, 81, 82, 86, 89, 106, 108-109, 139, 141, 144 (*see also under* Fatigue, 187-195)
 improvement of working methods, 11-12, 39 (Gilbreth, Taylor), 43-47 (Gilbreth, McKillop, Taylor), 57, 58-59, 109, 142
 inefficiency under low wages, 10
 influences, objective and subjective, 39, 57-58, 82, 190-191
 lack discrimination, 1
 means of increased productivity, 11, 15, 27, 44
 recreation and leisure, 5, 16, 19, 59, 82, 107-108, 177
 safety depends on employer, 86
 selection of:
 analysis of methods, 30-32, by actual trial, 31-32, by personal impression, 30-31, by physical fitness, 105-106, by psychological tests, 32-34, importance, 53, 175
 training in self-government, 169
 wasted energy under unintelligent conditions, 39, 82
 women and cost of living, 7-9
 women and shorter hours, 81

THE END

